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Office of Research and Development
Research Triangle Park, North Carolina

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This is the Annual report of the office of Research and Development at Research Triangle Park, EPA. The Office of Research and Development is a large research organization whose basic programs encompass air pollution, pesticides pollution, and radiation pollution. This summary provides a brief discussion of some of the major accomplishments of the research program during 1974 and indicates its future direction.

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ANNUAL REPORT 1974

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
Research Triangle Park, N.C.

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The cover presents an artist's concept of a building designed to conserve limited energy resources and reduce air pollution and also to meet the housing requirements of EPA's diverse research activities in North Carolina. The need to "build for the environment" is discussed in the Special Features section of this report.

ANNUAL REPORT
1974
OFFICE OF RESEARCH AND DEVELOPMENT
RESEARCH TRIANGLE PARK
NORTH CAROLINA

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
Research Triangle Park, North Carolina

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"I want . . . to underscore my conviction that our major environmental laws – in particular, the Clean Air and Water Acts – are good laws. Their primary purpose is to protect the public health and welfare, and we have made real progress toward achieving that purpose. We have, in the process, learned enough – and, as in most educational experiences, suffered on all sides a sufficient measure of pain – to make some very real improvements in both the laws themselves and the way EPA carries out those laws." Russell Train, Administrator of the U.S. Environmental Protection Agency, speaking to the National Association of Regional Councils, May 1975.

PREFACE

In July 1975, the National Environmental Research Center – Research Triangle Park, and the other three NERC's within the Office of Research and Development (ORD), were abolished as organizational entities. The several laboratories comprising the NERC's were reorganized into independent laboratories reporting directly to the U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C.

At NERC-RTP, the seven Laboratories formerly comprising the Center were reorganized into the four new Laboratories that now comprise the Office of Research and Development at Research Triangle Park (ORD-RTP). These Laboratories are:

- *HEALTH EFFECTS RESEARCH LABORATORY* – Consisting of the former Human Studies Laboratory, Experimental Biology Laboratory, Pesticides and Toxic Substances Effects Laboratory, and Special Studies Staff
- *ENVIRONMENTAL SCIENCES RESEARCH LABORATORY* – Consisting of the former Chemistry and Physics Laboratory and Meteorology Laboratory
- *INDUSTRIAL ENVIRONMENTAL RESEARCH LABORATORY* – Consisting of the former Control Systems Laboratory
- *ENVIRONMENTAL MONITORING AND SUPPORT LABORATORY* – Consisting of the former Quality Assurance and Environmental Monitoring Laboratory

Although the Laboratories have undergone an organizational change, most of their activities and research emphases remain unchanged. Thus this Annual Report for 1974, in describing the Laboratories and presenting a summary of their research accomplishments during 1974, accurately reflects these same Laboratories in their new organizational structure.

As in our Annual Report for 1973, we have included a discussion of the responsiveness of our research activities to Congressional desires. Expressed in the form of legislative mandates, these desires give direction to the operation of the Environmental Protection Agency and of other Federal agencies as well. We hope that in reading this report you will better understand the role of the Congress and the Executive Branch in establishing an environmental policy and the action taken by a Federal agency to fulfill the intent of this policy. Comments on this report and our activities are welcome.

JHKnelson

John H. Knelson
Senior ORD Official, RTP
Research Triangle Park, North Carolina

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

THE ENVIRONMENTAL PROTECTION AGENCY'S Office of Research and Development at Research Triangle Park, N.C. (ORD-RTP) is a large, multidisciplinary research organization where scientists concentrate their efforts on developing bases for improving the environment. Basic research and development programs at ORD-RTP encompass air pollution, pesticides pollution, and radiation pollution. This summary provides a brief discussion of some of the major accomplishments of the research program during the period of this report and indicates its future direction.

Air pollution research and monitoring projects range from the determination of the human health effects of exposure to pollutants to the evaluation of devices for the measurement and control of air pollutants. The health effects effort is focused in two principal areas: observation of pollutant effects on humans and observation of pollutant effects on smaller life forms, both *in vivo* and *in vitro*. Monitoring efforts concentrate principally on methods development, on quality control, and on special studies, such as the Los Angeles Catalyst Study, which is designed to determine the impact of emissions from the new automotive oxidation catalyst. Activities in the field of environmental sciences range from instrumentation development programs to modeling studies of meteorological transport and transformation. Projects in the field of control technology concentrate principally on the development and demonstration of cost-effective controls for reducing emissions from stationary sources.

Health Effects Research

In human health effects research, several new pilot studies were initiated during 1974. For example, admissions to the emergency room of a large hospital were investigated as a potential health indicator of sensitivity to varying concentrations of ozone in the ambient air. Another study investigated the impact of ozone on daily mortality. Preliminary information concerning the effects of ozone and oxides of nitrogen on pulmonary function has also been provided by the Ranchos Los Amigos Hospital in California.

A monograph presenting data on the health consequences of exposure to suspended particulates was completed and publication is expected in 1975. In other research, carbon monoxide effects studies demonstrated that the physical work performance of

Using roadside monitoring equipment, EPA is conducting a special study in Los Angeles, CA, to determine the impact of emissions from the oxidation catalyst device used on new automobiles.

healthy young men decreased when their carboxyhemoglobin levels reached 5 percent. Investigations with dogs showed that the incidence of myocardial infarction increased as carboxyhemoglobin levels rose above 5 percent. These studies will be expanded in 1975.

The new Community Health Air Monitoring Program (CHAMP), a field monitoring system, was installed and made operational. This system employs state-of-the-art continuous air quality measuring instruments connected with computers to give rapid access to air quality information from selected sites in California, Utah, Alabama, New York, and North Carolina. In addition, a major expansion of human health effects laboratory facilities was completed; the neurobehavioral laboratory, the microbiology laboratory, the metabolic laboratory, and the cardiopulmonary laboratory became fully operational in September 1974.

Studies of pollutant effects on smaller life forms produced information on the effects of oxides of both sulfur and nitrogen, krypton-85, tritiated water, and nonionizing radiation. Using isolated cells, perfused lung, and whole animals, investigators carried out studies of the influence of sulfuric acid, sulfur dioxide, and various sulfates. A recently constructed dynamic reaction chamber provided a medium for studying exposures in simulated natural atmospheres. Using the chamber, investigators found that guinea pigs inhaling sulfuric acid aerosol experienced a 50 percent increase in the number of particles deposited in the lungs and airway passages. A shift in the deposition pattern to upper airways was observed, suggesting a physiologic basis for the high sensitivity of asthmatics to sulfur oxides.

An *in vitro* screening system, using rabbit alveolar macrophages was fully developed as a means of estimating the relative toxicity of soluble and insoluble particulate air pollutants. This system is currently being employed to estimate the relative toxicity of air samples from stationary sources.

Another system that employs rapidly dividing human lung fibroblasts to test for compounds that inhibit cellular biosynthetic activities has been developed. The system has already been used to detect a preferential inhibition of DNA synthesis by relatively low concentrations of tetravalent platinum. Pentavalent vanadium and divalent cadmium were also determined to be highly cytotoxic. Facilities at RTP were essentially completed for implementation of *in vitro* test systems to detect potential carcinogens.

Programs in ionizing radiation health effects research are presently confined to tritium and krypton-85, two major effluents from the nuclear power cycle. During the reporting period, two studies on tritium were completed: one on the effects of chronic exposure to tritiated water (HTO) throughout gestation, and the other on the sensitivity of different aged populations to chronic HTO exposure. Research into the physiological and behavioral effects of krypton-85 is aimed at providing data for a realistic assessment of exposure hazards. Guinea pigs exposed to doses of krypton-85 up to 20,000 rads all survived the acute post-exposure period and are being observed for life span shortening, lung effects, and appearance of skin tumors.

Investigation of nonionizing radiation (from such sources as radar installations and high voltage transmission lines) are conducted as part of a multi-agency "Program for Control of Electromagnetic Pollution of the Environment: The Assessment of Biological Hazards of Nonionizing Electromagnetic Radiation," which is coordinated by the Office of Telecommunications Policy. Animal models are used to investigate potential genetic, biochemical, immunological, teratological, and neurobiological effects of exposure to radio and microwave frequencies. Studies are designed to identify potential harmful effects, to establish the exposure levels at which these effects are elicited, and to delineate the mechanisms of physical alterations.

A significant portion of ORD-RTP pesticide health effects research was directed toward evaluating the effects of pesticides and their residues on laboratory animals and to extrapolating these results to similar human exposures. For example, high concentrations of an experimental organophosphate insecticide were found to cause irreversible paralysis in animals. The significance of this finding to humans will be evaluated using a newly developed, more sensitive procedure for determining low-level organophosphate exposure.

Similarly, exposure of primates to the pesticide carbanyl caused changes in both brain wave patterns and behavior at a concentration that approximates the background exposure levels experienced by humans. The significance of these findings with respect to humans is under active investigation.

Monitoring and Support

The ORD-RTP monitoring efforts encompass several major areas: a methods standardization and performance evaluation program, a quality assurance program, a National Air Surveillance Network, a Fuels Surveillance Network, a Membrane Filter and Precipitation Network, a continuous air monitoring program, and a technical assistance program.

The methods standardization and performance evaluation program showed considerable progress in 1974. Published reports described results of collaborative tests of source emission measurement methods for nitrogen oxides, sulfur dioxide, particulates, and beryllium; of methods for Orsat gas analysis; and of velocity and moisture measurement techniques. Another collaborative test demonstrated the general reliability of the regulatory method for measuring carbon monoxide emissions from refinery catalytic cracking regenerators. Of particular current importance because of its association with energy production problems was a field study of the regulatory method for measuring sulfur dioxide and sulfuric acid mist emissions using a ganged probe sampling assembly. The test indicated that, under rigidly controlled conditions, the sampling train is capable of giving reproducible results. Results of another evaluation and collaborative test program caused the revision of four of the regulatory methods promulgated with the New Source Performance Standards of December 23, 1971.

In tests of measurement techniques under the quality assurance program, the sodium arsenite, TGS-ANSA, and chemiluminescence methods for measuring nitrogen dioxide in ambient air proved reliable in the hands of the average user; however, the continuous colorimetric method was judged unreliable under the same conditions.

Several guidelines were developed and published in 1974 to accompany appropriate reference methods – four for ambient air techniques, three for stationary sources, one for lead, and one for phosphorus in gasoline.

An automated system of data acquisition programmed to yield precision data, with built-in quality assurance checks and numerical regression analysis routines, has afforded rapid generation of validated data for the National Air Surveillance Network during 1974.

During 1974, ORD-RTP scientists also performed analyses of the samples collected by the Fuels Surveillance Network in 1973. A National Bureau of Standards Standard Reference Material for lead in reference fuel was developed. The Environmental Protection Agency, the National Oceanic and Atmospheric Administration, and the World Meteorological Organization continued to operate jointly a 20-station precipitation network for trace metals analysis.

Investigators also initiated a long-term study in Los Angles, California, to determine the impact of emissions from the new automotive oxidation catalyst on ambient air. Background data from four stations adjacent to the San Diego Freeway will identify existing air quality parameters prior to the appearance of catalyst-equipped automobiles in large numbers.

Environmental Sciences Research

The principal efforts in the field of environmental sciences research involved development and evaluation of air quality models; studies of the physical and chemical transformations of pollutants from source to receptor in the atmosphere; determination of the effects of pollutant and thermal emissions on visibility, weather, and climate; development of techniques and instruments for measuring pollutants at point sources and in ambient air; and support of abatement and compliance efforts.

An analysis of past model verification studies revealed that none of the photochemical models adequately represent the observed data for nitric oxide, nitrogen dioxide, and ozone. The analysis did show, however, that two of the carbon monoxide models were acceptable. Definite inadequacies in the chemical kinetic mechanisms used in simulating photochemical smog formation were indicated.

Investigators identified and described transformations of sulfur oxides, nitrogen oxides, and organic pollutants, and made progress in establishing reactivities and reaction paths. Intermediate chemical species as well as final oxidation products continue to be identified and measured.

Previous studies in the Los Angeles Basin have suggested that high ozone levels observed in nonurban areas result from the transport of oxidants and their precursors from large urban areas. More recently, data from nonurban areas of West Virginia, Ohio, Florida, and New York have produced similar results. In an extension of these urban/nonurban pollution studies, results demonstrated that precipitation scavenging of inorganic pollutants by convective storms can be extremely effective in removing urban pollutants from the atmosphere. Measurements made at various distances downwind of an urban area (St. Louis, Missouri) indicate that precipitation scavenging removal rates can be comparable to urban emission rates.

Although research programs on halogenated pollutants have been underway for several years, recent findings on ozone-freon interactions in the stratosphere have given new urgency to studies in this area. Studies include field measurement of ambient levels of halogenated compounds, laboratory studies of photochemical reactions, determination of diffusion rates, and delineation of removal processes.

Investigations also continued on the physical and chemical properties of aerosols at their source in the air. The major sinks for aerosol pollutants and their removal rates are being defined. In addition, the effects of the aerosols on gas-phase atmospheric chemical reactions are under investigation, along with the gas/particle conversions and the particle removal processes. Various detailed studies aimed at producing scientific data basic to the promulgation of fine-particle criteria and standards and to the development of effective control procedures were also continued during the year.

A team of experienced aerosol scientists was assembled in St. Louis in the summer of 1973 and 1974 to conduct an intensive aerosol characterization program using special mobile facilities. Two gaseous pollutant transformation projects are still underway: the first is the study of the transformations of nitrogen oxides and sulfur oxides in power plant plumes; the second involves laboratory verification of the kinetic models that are to be applied to the network data.

A major accomplishment during 1974 was the development of a simple, sensitive, and reasonably specific device for the automated collection and quantification of sulfuric acid mist.

The Regional Air Pollution Study (RAPS) produced two separate, laserpowered, long-path spectrophotometers for use in determining gaseous pollutant burdens, averaged over line-of-site paths of up to 1 kilometer. Data obtained from these instruments will contribute to the improvement of pollution-transport modeling capability. These instruments are capable of analyzing for carbon monoxide, ozone, and sulfur dioxide. Investigators also developed a simple monitor for vinyl chloride concentrations. The level of its sensitivity suggests that it may be useful in monitoring exposure levels of industry workers. Under contract, investigators also developed a small, lightweight monitor for carbon monoxide in ambient air based on the nondispersive optical absorption technique for gas filter correlation.

Particulate sampling studies produced two new instruments — an automated dichotomous sampler that separates respirable from nonrespirable fractions and a Beta-gauge for assessing the mass of particles in each fraction collected. In studies of airborne asbestos, the scanning electron microscope was found to be useful in identification and measurement of fibers, and the feasibility of an X-ray diffraction method for rapid quantitative analysis of airborne abestos samples was demonstrated.

During the year, the mobile source emissions measurement program developed methods for the routine measurement of sulfate emissions from both catalyst-equipped and non-catalyst vehicles. These methods produced data showing significant increases in sulfate emissions from catalyst-equipped cars and formed the basis for initial projections of their future impact on air quality. Engine dynamometer tests of various commercial catalyst packages showed considerable differences in the tendency to produce sulfate and suggested possible technological changes for minimizing sulfate emissions.

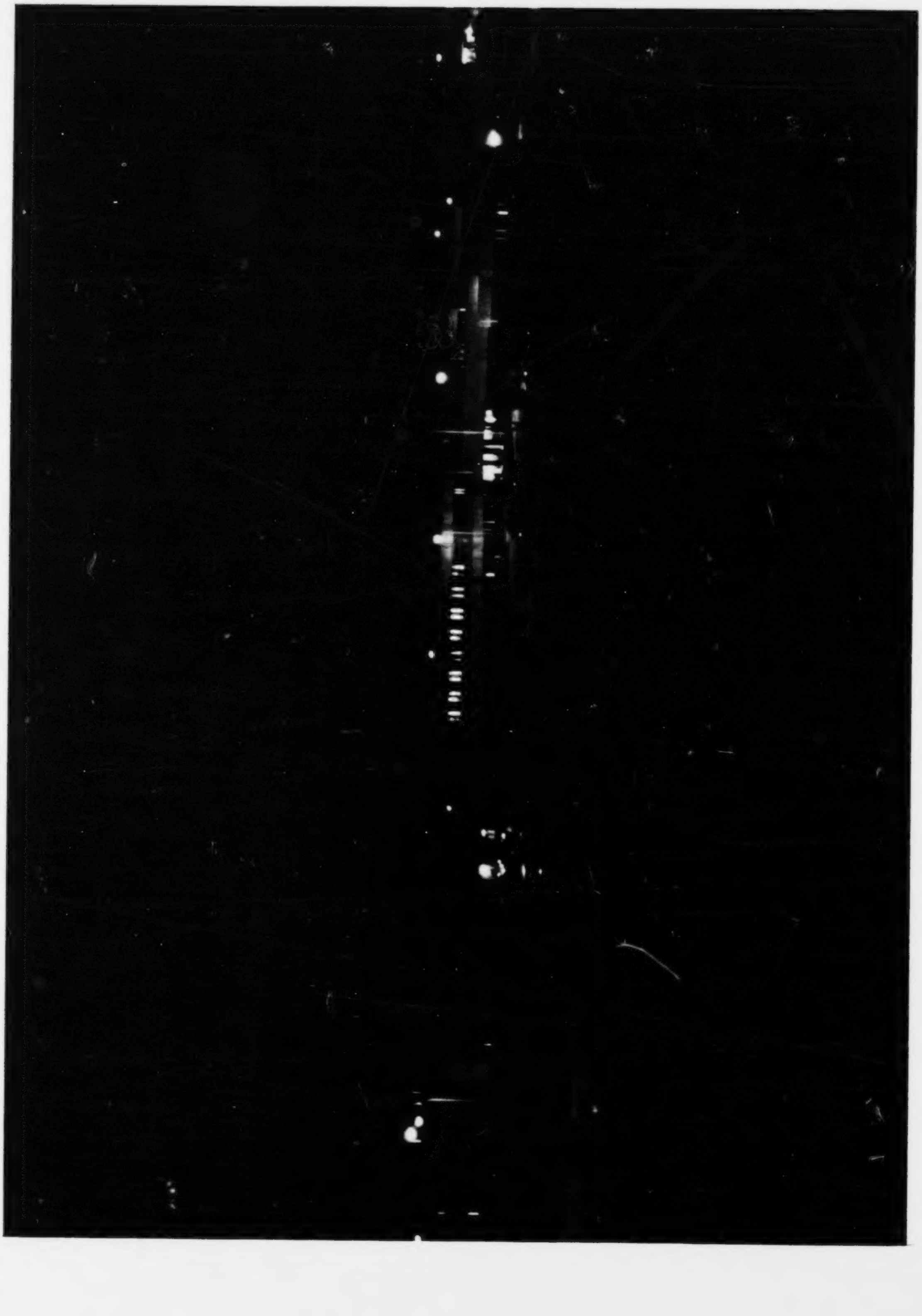
Industrial Environmental Research

Measurable progress has been achieved in developing technology for stationary source air pollution control. On the pressing problem of fine particulate matter (particles less than 3 micrometers in diameter), approaches to improvement of conventional control devices have been defined, and laboratory testing of new detection and removal concepts has been accomplished. Among the "conventional" devices, field tests demonstrated that properly designed and operated electrostatic precipitators can be more than 90 percent efficient on a mass basis in collecting all particle size fractions down to about 0.01 micrometer in diameter. Experimental work by ORD-RTP to aid in selecting optimum fabric filter cleaning methods was described in a 1974 report. Test programs were initiated to evaluate two new particulate control devices, the sonic agglomerator and the steam-hydro scrubber; feasibility studies were completed on the use of charged droplets and condensation effects to improve fine particle collection.

The emission of sulfur oxides has been a major concern in stationary source air pollution control. The flue- gas cleaning demonstration projects that are presently underway are expected to attain 60 to 97 percent efficiency in removing these pollutants. Laboratory and bench-scale tests proved the technical feasibility of removing inorganic sulfur from coal; design of a pilot-plant operation was begun. Studies of coal gasification and conversion processes and of versions of fluidized-bed coal combustion and residual oil combustion to reduce sulfur oxides emissions (particularly for steam and power generation) were continued during 1974.

In studies of nitrogen oxides, investigators delineated techniques capable of reducing nitrogen oxides emissions from coal-fired boilers by as much as 50 percent. Other studies demonstrated commercially feasible means of reducing carbon monoxide, hydrocarbons, and particulate emissions from coke ovens by 90 percent.

INTRODUCTION



INTRODUCTION

THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY is charged with mounting an integrated, coordinated attack on pollution, and with filling the need for a strong independent agency to serve as an objective, impartial arbiter of environmental matters, particularly in establishing and enforcing pollution control standards. The creation of EPA in 1970 marked the end of the piecemeal approach to our nation's environmental problems that had so often in the past inhibited progress, or had merely substituted one form of pollution for another. Most important of all, perhaps, the creation of EPA gives to the American people a single agency to serve as their advocate for a livable environment, making possible more sensible choices about what constitutes a healthful, satisfying milieu for human life.

The Environmental Protection Agency is, first and foremost, a regulatory agency, having responsibilities for establishing and enforcing environmental standards within the limits of various statutory authorities. The process of setting standards, however, begins with a scientific research and monitoring program. For just as a physician must know the nature of the illness before he can treat the patient, we must know the nature of pollutants before we can treat our environment. If pollution cannot be detected, identified, and measured, it cannot be controlled.

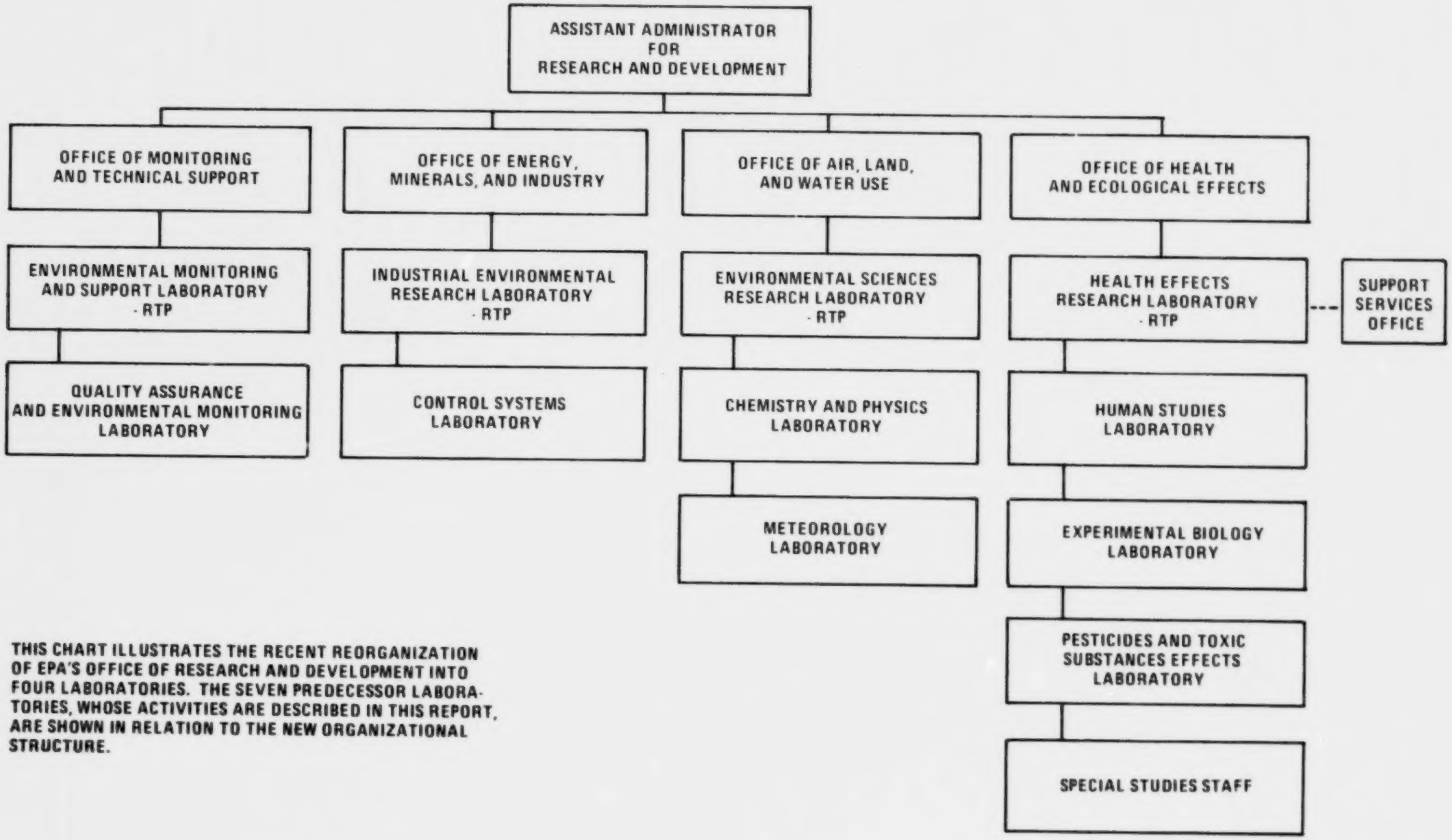
Where do pollutants come from? How can they be identified and measured? What are their effects? How can they be controlled?

Scientific investigation provides the answers to these questions. Sources of pollution are identified through research. Research tells us what a specific level of a specific pollutant does to human beings; to crops and other vegetation; to domestic animals and wildlife; to plant and animal life in a body of water; to concrete, steel, and other building materials; to painted surfaces; and to fabrics. Research establishes threshold levels at which adverse effects from environmental pollutants, alone or in combination, might be expected. Research provides the basic scientific knowledge needed to safeguard public health and to balance the benefits of a specific product against the hazards it might pose for the environment.

Research, therefore, constitutes the essential scientific foundation for action to improve environmental quality. The Environmental Protection Agency gathers evidence from its own research studies, from scientific and technical advisory committees, from the scientific community, and from industry. The diversified research programs of EPA are carried out at the 15 Laboratories of the Office of Research and Development, 4 of which are located in the Environmental Research Center facilities at Research Triangle Park, North Carolina (ORD-RTP).

Highly specialized, multidisciplinary research programs directed toward improving the environment are conducted at EPA's Office of Research and Development facility at Research Triangle Park, NC.

ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
RESEARCH TRIANGLE PARK, NORTH CAROLINA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QUALITY ASSURANCE AND ENVIRONMENTAL MONITORING LABORATORY
CONTROL SYSTEMS LABORATORY
CHEMISTRY AND PHYSICS LABORATORY
HUMAN STUDIES LABORATORY
METEOROLOGY LABORATORY
EXPERIMENTAL BIOLOGY LABORATORY
PESTICIDES AND TOXIC SUBSTANCES EFFECTS LABORATORY
SPECIAL STUDIES STAFF

THIS CHART ILLUSTRATES THE RECENT REORGANIZATION OF EPA'S OFFICE OF RESEARCH AND DEVELOPMENT INTO FOUR LABORATORIES. THE SEVEN PREDECESSOR LABORATORIES, WHOSE ACTIVITIES ARE DESCRIBED IN THIS REPORT, ARE SHOWN IN RELATION TO THE NEW ORGANIZATIONAL STRUCTURE.

The research at ORD-RTP is conducted under the authority of four legislative acts:

- The Clean Air Act
- The Federal Insecticide, Fungicide, and Rodenticide Act
- The Federal Food, Drug, and Cosmetic Act
- The Public Health Service Act

In this Annual Report, an attempt is made to show how ORD-RTP research activities from January through December 1974 have been supportive of the Congressional mandates expressed in these Acts. The highlights of these research activities are discussed briefly in the "Executive Summary." Some of the national issues in which ORD-RTP has been involved in 1974 are described in the Special Features section. A summary of the pertinent portions of these Acts and the ORD-RTP programs that are directly supportive of the legislation can be found in the section entitled, "Legislative Mandates." The "Research Activities" section of the report describes in detail the scientific program of ORD-RTP as it relates to specific sections of the Acts – a relationship that is the theme of this report. The following discussion of ORD-RTP – its mission, its research program, and its national and international activities, as well as a summary of resources – is presented to make the legislative mandate theme more meaningful.

ORD-RTP Research Program

MISSION

The primary responsibility within the Environmental Protection Agency for the conduct and management of research program and related activities pertaining to air pollution has been given to the Office of Research and Development at Research Triangle Park. The general objective of activities at ORD-RTP is, therefore, a reflection of the stated purpose of the Clean Air Act; its research is tied to the statutory mandates of that Act. In addition to activities pertaining to air pollution, ORD-RTP has also been charged with the conduct of pesticides and radiation research, as specified in several other legislative acts.

The underlying purpose of the Clean Air Act is to protect and enhance the quality of the nation's air resources in order to promote the public health and welfare and the productive capacity of its population. Consequently, the protection and enhancement of both the quality of life and the productive capacity of the nation's population is the major goal of research conducted by ORD-RTP. Recognizing the overwhelming technical problems and economic costs to this country posed by a purpose of this lofty dimension and ensuring that solutions advanced for dealing with those problems are intelligible are equally important purposes of this Congressional mandate. Congress also stipulated two other purposes for the Act – to accelerate a national research and development program and to provide technical assistance to State and local governments. The mechanisms mandated by Congress for achieving the nation's environmentally related goals rely heavily on the use of standards to be promulgated by the Agency. Such standards are applicable specifically to the offending sources of pollutants and are designed to limit their emissions in accordance with appropriate environmental goals. The pollutant control standards must reflect both the cause-and-effect relationships between pollutant level and environmental impact and the technological feasibility of their implementation. The scientific knowledge necessary to define the environmental goals, the establishment of the role of emissions as they relate to these goals, and the engineering capability to ensure availability of control technology at reasonable costs with respect to societal, cultural, and economic consequences are all essential components of the mission of ORD-RTP. In addition, the conduct of research supporting the development of a reliable monitoring and surveillance capability – for use in following the progress in attaining environmental goals and ensuring compliance with the source standards – is ancillary to ORD-RTP's mission.

To obtain basic environmental goals, certain research objectives must be attained. Scientific knowledge necessary to define the goals includes an ability to assess the impact of environmental pollution on health and welfare. To make a valid assessment of the impact, the following objectives must be met through research:

- Identification of health and welfare indicators of environmental pollution.
- Identification of the chemical and physical nature of the environmental pollutants responsible for adverse effects.
- Development and application of measurement technology to establish pollution levels and define exposure patterns.
- Establishment of dose-response relationships and the mechanism of the pollutant action on the receptor.

To define the relationships between polluting sources and the environmental exposure pattern, the ORD-RTP mission includes the following objectives:

- Development and application of identification and measurement technology to characterize the chemical and physical nature of source emissions to the environment.

- Establishment of the patterns of movement of pollutants in the environment and the role of environmental factors in their transport.
- Definition of the nature and expense of the chemical and physical alterations that attend the movement of pollution through the environment.
- Development and validation of methods for simulating environmental exposure patterns and predicting optimum control strategy.

The engineering capability to control the emissions of environmental pollutants involves these ORD-RTP objectives:

- Characterization of pollutants.
- Development of laboratory and pilot-scale techniques and hardware for eliminating or minimizing emmisions.
- Construction of plant-scale demonstration projects to assess the effectiveness of control techniques.

Surveillance and monitoring objectives relate to the development and application of:

- Field-worthy techniques for large-scale population surveys to ascertain the benefits resulting from the control of environmental pollution and to determine the soundness of the standards upon which the controls are based.
- Measurement methodology for monitoring the impact of pollution controls on environmental exposure patterns.
- Measurement methodology for monitoring compliance with emissions standards and characterizing new pollutants resulting from control operations.

In the conduct and management of research related to the above objectives, the major "product" of ORD-RTP is the documentation of the scientific and engineering knowledge to provide a substantial information base upon which Agency-level decisions can be made.

NATIONAL RESEARCH PROGRAM

Research, and its ancillary undertaking of environmental surveillance, at both the national and the international level are essential to the appreciation of the complex and variable factors to be considered in the quest for national and international environmental improvement.

Specifically, ORD-RTP has the overall responsibility for the direction and conduct of EPA's research and development programs related primarily to the effects of air pollutants on health, and to the understanding of the physical and chemical processes that affect the emission, transport, transformation, and reception stages of the air pollution cycle. These programs are an integral part of EPA's closely coordinated total research program that strives to achieve a synthesis of knowledge from the biological, physical, engineering, medical, and social sciences that can be interpreted in terms of total human and environmental needs.

The development of the ORD-RTP research program is in direct response to the language and intent of several Congressional mandates, specifically the Clear Air Act (and amendments); the Public Health Service Act; the Food, Drug, and Cosmetic Act; and the Federal Insecticide, Fungicide, and Rodenticide Act. Results obtained through the ORD-RTP research program concerning the impact and the cause-effect relationships of pollution problems provide a range of knowledge necessary in the establishment of environmental pollution standards. The development of pollution control technology provides pollutant emitters with scientific capabilities for pollution control, thereby making compliance with air quality standards possible. ORD-RTP's monitoring program provides a verification of actual compliance with the standards.

ORD-RTP conducts research on a broad environmental basis to provide EPA with a sound scientific basis for control of environmental pollutants that adversely affect human health and welfare.

These programs emphasize the following major research activities:

- *Exposure and Source of Exposure*—These activities include development and standardization of techniques for measurement of pollutants, both at their source and in the ambient environment.
- *Effects of Exposure*—This work includes quantification of the effects of exposure to environmental pollutants on both health and welfare (including the development of techniques for assessing effects).
- *Strategy*—This research includes development of predictive models for environmental levels of pollutant emissions, reflecting transportation and removal processes.
- *Prevention of Exposure*—Activities in this area include development of cost-effective control technologies.
- *Pollutant Characterization*—Efforts include preparation of briefing reports, scientific summary documents, and criteria documents.

The development and standardization of techniques for the measurement of pollutants both at their source and in the ambient environment are necessary to accurately define the exposures and their source. Standards and regulations cannot be established until the extent and source of an exposure are identified. At ORD-RTP, techniques are being developed and standardized for defining both air quality and emissions. Emphasis will continue to be placed on gathering valid air quality and related data and on developing (refining) methodology for measuring pollutants. The chemical and physical transformations that pollutants undergo from source to receptor in the atmosphere are also being studied. Specialized monitoring and technical assistance services are provided to EPA Regional Offices and local air pollution control agencies in their endeavors to identify pollutants and their sources. The nationwide fuel surveillance network is operated to assess the potential impact of emission products from various emission control devices on atmospheric reaction processes. Exposure of various materials to pollutants is also an important aspect of this research area. Environmental samples are analyzed for a variety of trace metals and other pollutants, requiring development and standardization of monitoring equipment for specific elements.

It is important that standard methodology and adequate quality control be used to ensure the production of unimpeachable data and to maximize the validity and comparability of those data. Once the exposure to harmful substances and the sources of exposure are established, one major building block has been completed in the foundation of knowledge needed for making far-reaching national decisions on environmental control.

Another body of knowledge important to EPA in establishing and enforcing standards is the research concerned with the manner in which environmental pollutants (singly or in combination) cause specific undesirable health effects. This research includes animal studies, human clinical studies, and epidemiological studies on human populations. Major emphasis is placed on the collection of sufficient information for formulating environmental control strategies and thus providing bases for establishing national emission standards for pollutants or source categories that endanger human health or welfare.

The Community Health and Environmental Surveillance System (CHESS) is a national program of standardized epidemiologic studies organized within the past 4 years. The program is designed to measure environmental quality as it relates to chronic and acute health indicators in sets of communities representing exposure gradients to common air pollutants including particulates, sulfur oxides, nitrogen oxides, and photochemical oxidants. The CHESS program is essential in evaluating existing environmental standards, in obtaining health intelligence for new controls, and in documenting the health benefits of air pollution control.

Clinical research is being conducted in the area of exposure effects to obtain data on gaseous and particulate air pollutants relevant to the development of standards for the protection of human health and welfare. These studies are supportive of the standard-setting processes in the following ways:

- Validating data from human studies.
- Providing clues to new human studies.
- Indicating the potential harmful effects of new pollutants.
- Ascertaining the adequacy of safety margins through interaction studies.

A specific research area in the study of pollutant effects on human health and welfare is the research pertinent to providing data necessary for the intelligent assessment of the hazards to human health of exposure to pesticides, toxic substances, substitute chemicals, and combinations of these with each other and with other environmental factors. To obtain these data, toxicity studies are conducted in which various animal species are used as models. Methods for measurement of human exposure to pesticides and toxic substances are developed and improved, and a quality assurance program is conducted to ensure the accuracy of analytical results. The studies are concerned with identifying pesticides, their metabolities, and any adverse effects on normal biological functions. In these subject areas, research provides data needed by the Agency in meeting its legally mandated responsibilities in registering, labeling, setting of tolerance levels and limiting the misuse of pesticides.

Results of ORD-RTP's research on the effects from pollutant exposure are used in formulating and revising environmental quality criteria. The epidemiologic studies have been oriented toward defining environmental hazards and providing data on which to base standards. Biological research is designed to detect, define, and quantify the effects of environmental pollution. Collectively, the data generated by ORD-RTP's research on exposure effects form a major part of the information system that the Agency uses to set and enforce standards.

Relevant to the Agency's need to make control decisions is the information derived from the meteorological aspects of air pollution, including theoretical and experimental studies of the physical properties that affect the transport, diffusion, transformation, and disposition of air pollutants in and from the atmosphere. Through this research, techniques and methods of forecasting potential air pollution episodes are improved. Analytical diffusion models are developed to predict the temporal and spatial distribution of air pollutants; they are also useful for preevaluating proposed air pollution control strategies. Studies are also conducted on the effects of air pollutants on the geophysical processes of weather and climate as well as on the energy balance of the earth-atmosphere system. ORD-RTP's research program also includes development of remote-sensing techniques for measuring meteorological parameters in urban areas.

Chamber and field studies are used to investigate physical and chemical characteristics, transformations, and effects on materials of emissions of sulfur oxides, carbon monoxide, nitrogen oxides, hydrocarbons, and other organics; and in assessing their role in producing sulfates, nitrogen dioxide, nitrates, ozone, organic aerosols, and other finely divided particulate materials in the atmosphere. Because the consequences as well as the fate of environmental pollution can be anticipated from this and other information, the Agency can develop strategy to be used in its program of establishment of enforcement standards.

ORD-RTP's fourth major area of emphasis, prevention of exposure, can only be accomplished through the development of the technology required to control air pollution sources in a timely and cost-effective manner. The Agency does not stipulate the control technology to be used to meet the standards it has established; however, the Agency is required by law to publish a control technique document that provides information on how affected sources can meet a particular standard before that air quality standard is "official." Much research is needed to develop control techniques that reflect the best available technology; therefore, a large part of the ORD-RTP research effort is concerned with the conduct, direction, and management of engineering research, development, and demonstration programs leading to the abatement of air pollution from major stationary sources. Laboratory activities encompass development and improvement of control devices such as scrubbers, filters, and electrostatic precipitators; complete effluent-gas-treatment processes; combustion methods and equipment; fuel preparation technology; and associated sampling and analysis instrumentation systems. Improved control technology must be developed before new source performance standards can be established and hazardous pollutants controlled.

Another important element of control in the area of exposure prevention is the Fuels and Fuel Additives Registration program. The Program consists of registering the chemical composition, the purpose of use, and the recommended concentration of additives used in motor gasoline that is introduced into interstate commerce. Fuel and fuel additive manufacturers are required to provide quarterly data on the use of registered additives as well as information concerning the mechanism of action and the effects on exhaust products, if known. In addition, protocols have been developed to assess the effect of fuel components on control device performance, which will result in information that may be used in the control or prohibition of fuel components or additives pursuant to the 1970 Clean Air Act Amendments — in a time frame to ensure public safety and satisfactory performance of advanced automotive control systems.

The results of the previously described research programs are used to prepare briefing reports, scientific summary documents, and criteria documents as required by the Clean Air Act Amendments. According to the law, the Administrator of EPA is required (from time to time but as soon as practical) to develop and issue to the states such criteria of air quality as, in his judgment, may be required for the protection of the public health and welfare. Such criteria shall reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on health and welfare that may be expected from the presence of an air pollutant.

Defining the biologic effects of specific air pollutants on humans, animals, and vegetation, as well as non-biological effects such as modification of visibility and deterioration of materials, is a major effort of ORD-RTP. This activity, termed pollutant characterization, also includes gathering qualitative and quantitative information on the sources, form(s), reactivity, methods of collecting and quantitating, and strategies for controlling pollutants. In promulgating standards, the legally defensible basis must include scientifically sound assessment of comprehensive scientific data as reported in criteria documents. The need for additional research for producing adequate criteria to permit the issuance or revision of standards must also be identified. These papers (or scientific summary documents) are also developed for non-criteria pollutants to indicate the need for control and to recommend control strategy.

Collecting, reviewing, evaluating, comparing, summarizing, and interpreting pertinent information and literature to prepare criteria documents, briefing reports, and scientific summary documents on non-criteria pollutants are functions performed at ORD-RTP. In the preparation of the reports, the data generated by the entire research program at ORD-RTP converge with all other available literature and research to form the basis needed to produce scientifically sound documents. ORD-RTP, in some cases, contracts with the authoritative sources — one being the National Academy of Sciences — to review the information that is available on some pollution issues. ORD-RTP personnel then use these reviews in the assessment of the problems and in the development of pollutant characterization documents. These documents are then added to the Agency's data base that provides pertinent information for making decisions on the need to control emissions of a pollutant and deciding upon actions to be initiated.

INTERNATIONAL RESEARCH PROGRAM

Among the regular functions of ORD-RTP are a wide variety of international activities that, although not organized under a separate functional entity, are carried out as a logical extension of ORD-RTP's research program as described in the preceeding section. Because these international activities constitute a rather sizeable contribution to the resolution of world environmental problems, it is appropriate to consider them briefly in the context of their relationship to ORD-RTP's major objectives.

As a part of its efforts toward development and standardization of measurement techniques, ORD-RTP makes what is probably its most significant contribution to international pursuits. Designated by the World Health Organization as an International Reference Center for Air Pollution Control, ORD-RTP provides manuals for air pollution monitoring systems, recommends reference methods for pollutants, and operates an International Aerometric Data Bank that receives, processes, analyzes, and publishes data from 50 monitoring stations in 14 countries.

The World Meteorological Organization also draws upon ORD-RTP support for operation of a turbidity monitoring network and for its services as an international referee laboratory for precipitation chemistry.

Contributions in the area of measurement and standardization are also made to the Organization for Economic Cooperation and Development's (OECD) Air Management Sector Group.

Under the auspices of several formalized cooperative agreements, ORD-RTP participates in the development and standardization of measurement methodology with the Union of Soviet Socialist Republics through the U.S. – U.S.S.R. Agreement on Cooperation in the Field of Environmental Health, and with the Government of Spain through the Frontiers of Science Program of the National Science Foundation.

Measurement techniques are also studied through the mechanism of EPA - funded and ORD-RTP supervised contracts in Austria and France, and through various exchange programs in which scientists from such countries as Czechoslovakia and Spain work in ORD-RTP laboratories under the supervision of Staff scientists.

Research on the effects of pollutant exposure is carried out by ORD-RTP in cooperation with several international groups. Research emphasis in the U.S. – Federal Republic of Germany Agreement on Protection of the Environment, for example, centers on the role of combustion products in human carcinogenesis. Staff scientists are also participating in the U.S. – U.S.S.R. Agreement on Cooperation in the Field of Medical Science and Public Health through a time-dose study of nitrogen dioxide.

In addition, under the direction of ORD-RTP project officers, contracts under the Special Foreign Currency program have been granted in Egypt, India, Poland, and Yugoslavia to address various aspects of exposure effects research, principally in the area of effects of atmospheric metals on health.

ORD-RTP assists or participates in epidemiologic studies of pollutant exposure with such groups as the Commission of the European Economic Community (Common Market) through a comparative study of respiratory disease in school children and with the Pan-American Health Organization by assisting in the design and initiation of a study in Mexico on the effects of heavy metals. A portion of the U.S. – U.S.S.R. Agreement on Protection of the Environment also involves ORD-RTP epidemiologists in a study of the biological and genetic effects of pollutants; two Special Foreign Currency contracts in Yugoslavia also address epidemiologic aspects of pollutant exposure.

Control strategy research through the development of predictive models is the prime consideration of the North Atlantic Treaty Organization Committee on Challenges of Modern Society (NATO/CCMS) in its Panel on Air Pollution Modeling, the only Panel of the original four which is still in existence (the others having completed their assignments). Through 1974 the United States was the Pilot Country for this Panel, and to fulfill this responsibility staff meteorologists provided the extensive input necessary to coordinate the Panel's annual meetings. The Federal Republic of Germany is expected to assume the Pilot Country role in 1975.

A second large modeling study involving meteorologists, chemists, and engineers of ORD-RTP is being carried out through the U.S. – U.S.S.R. Agreement on Cooperation in the Field of Environmental Health.

Air pollution modeling has also been the subject of exchange visits by scientists from Norway and the United Kingdom, whose fellowships were funded by the NATO/CCMS.

Prevention of exposure through the development of control technology is being studied cooperatively with several international groups. Perhaps the largest effort in this area is under the auspices of the U.S. – U.S.S.R. Agreement on Protection of the Environment. Under Subtopic 2, "Stationary Source Air Pollution Control Technology," engineers of the ORD-RTP are participating in studies of particulate abatement, gaseous emissions abatement, and process modification. Staff engineers have also participated in several seminars sponsored by the Economic Commission for Europe in the area of improved combustion technology.

Special Foreign Currency projects in Poland and Yugoslavia consider various aspects of control technology or improved combustion processes; international contracts with investigators in France and the United Kingdom also study these problems.

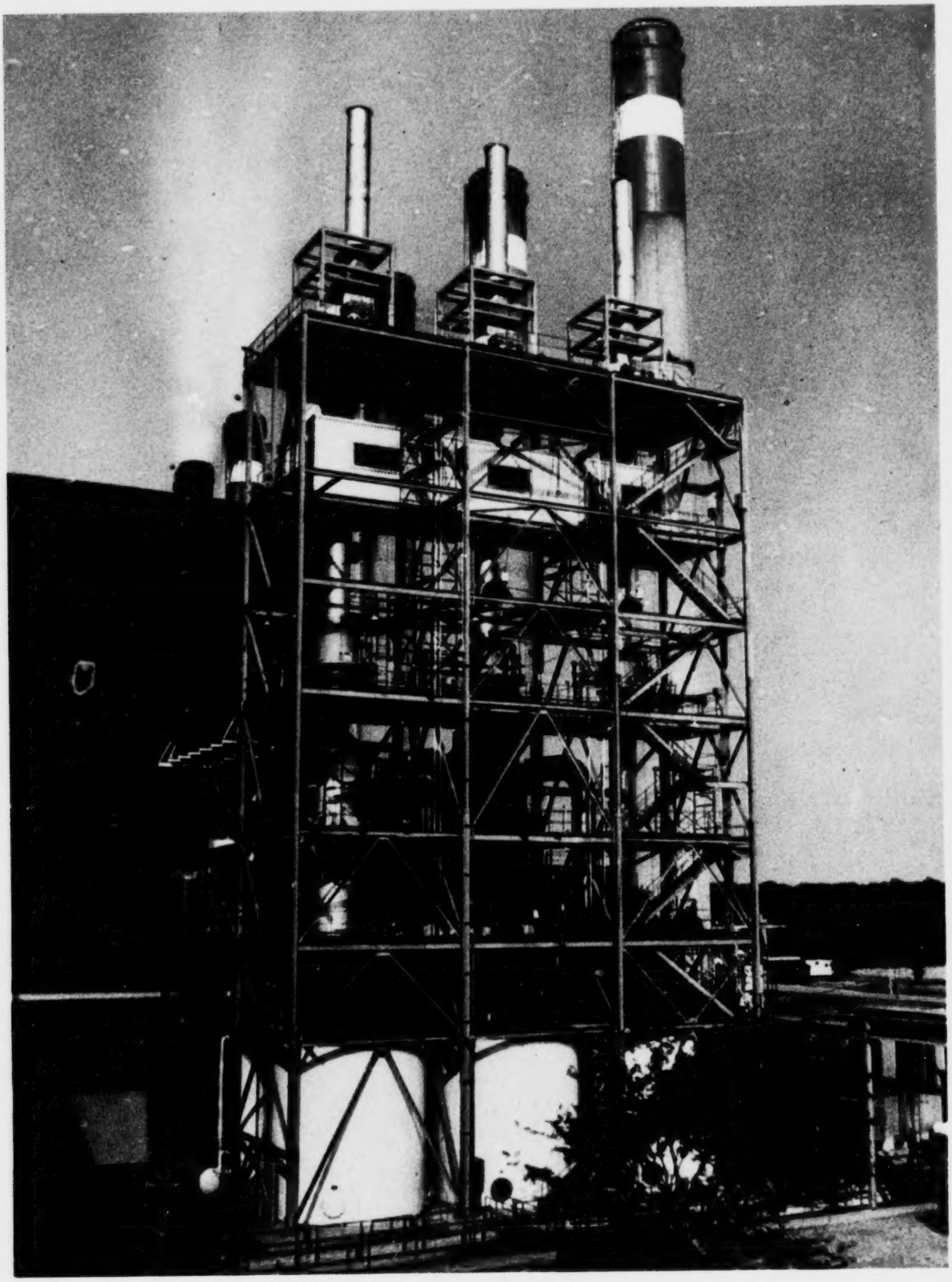
As one of the more important first steps in attacking pollution problems in developing areas, pollutant characterization is of substantial significance in ORD-RTP's international activities. The writing of assessment and state-of-the-art documents continues on a fairly large scale with several international organizations. Recent ORD-RTP contributions, for instance, to the WHO Environmental Health Criteria Programme include *Environmental Health Criteria for Manganese and its Compounds,* and *Environmental Health Criteria for Polychlorinated Bi– and Terphenyls.*

The OECD's Air Management Sector Group, through its ORD-RTP Chairman and permanent delegate, also calls upon ORD-RTP from time-to-time for case history and assessment documents. Recently, two case history reports, *The Problem of Photochemical Oxidants in the Ambient Air of the USA: A Case History Report,* and *Case History on the Use of Criteria and Effects Data as the Basis for Decisions on the Control of Sulfur Dioxide in the United States* were written by Staff scientists.

The need for assessment documents was highlighted during the year in a meeting between ORD-RTP representatives and officials of the Federal Republic of Germany. As a result of this meeting, ORD-RTP has already provided draft reports on particulate polycyclic organic matter, polychlorinated biphenyls, suspended sulfates and sulfuric acid aerosols, cadmium, manganese, and vanadium and will provide other reports and annotated bibliographies upon request.

As a widely recognized source of expertise in air pollution research, ORD-RTP often provides briefings for international scientists concerning areas of mutual interest and responds to requests for information and assistance. Responding to these requests is seen not only as a means of assisting other countries to reach their pollution abatement goals and as a means of promoting international good will, but also as a means of gaining valuable new insights that will speed our own country's progress towards its goal of improved environmental quality.

SPECIAL FEATURES



SPECIAL FEATURES

EACH YEAR MANY ORD-RTP programs reflect, in varying degrees, significant areas of effort relating to EPA's overall goal of reclaiming the purity of the nation's environment. This portion of the Report focuses on four programs that are of significance because of their nationwide impact: the application of control technology (primarily scrubbers) to major stationary sources such as electric power plants, the reduction of automotive emissions through the use of oxidation catalysts, the use of pesticides and their relation to the environment, and the incorporation in building design of new concepts to enhance the conservation of both energy and the environment.

Scrubbers and Electric Power Plants (SO_x Control)

INTRODUCTION

Sulfur dioxide (SO_2) and the products it forms in the atmosphere are among the most dangerous air pollutants to human health. In addition, SO_2 concentrations presently occurring in ambient air are clearly harmful to vegetation, buildings, and materials. The cost to society resulting from SO_2 pollution, although difficult to quantitate precisely, amounts to billions of dollars per year.

Most manmade SO_2 in the atmosphere results from the combustion of sulfur-containing fossil fuels such as coal and petroleum. In 1973, more than 33 million metric tons (36 million tons) of SO_2 were emitted to the atmosphere in the United States; approximately half of this total was directly attributable to electric power plants. It is projected that power plants alone will emit 73 million metric tons (80 million tons) of SO_2 in the year 2000 unless pollution control technology is used to reduce the emissions. These current and projected SO_2 emissions clearly indicate the immediate need for the development and application of SO_2 emission control technologies with emphasis on the control of the major source: electric power plants.

Environmental Legislation

The magnitude and potential national impact of the air pollution problem prompted Congressional action in the form of the Air Quality Act of 1967 and the Clean Air Amendments of 1970. The Air Quality

ORD-RTP conducts demonstration projects of methods (such as lime/limestone flue gas scrubbing) for reducing concentrations of dangerous atmospheric pollutants resulting from the combustion of fossil fuels containing sulfur.

Act required the establishment of a national research and development program for the prevention and control of air pollution, and the 1970 Amendments instituted a schedule for the reduction of SO_2 emissions from stationary sources including both existing and new power plants. The responsibility for establishing a control program, setting emission standards, and developing and demonstrating technology that could achieve the emission standards was charged to the Environmental Protection Agency (EPA). In April 1971, EPA established primary National Ambient Air Quality Standards (NAAQS) for SO_2 at 80 $\mu g/m^3$ as the annual arithmetic mean and 365 $\mu g/m^3$ as the maximum 24-hour concentration not to be exceeded more than once per year. Attainment of the NAAQS was required by mid-1975; any extension of that deadline would require Congressional amendment to the previously passed environmental legislation.

New Source Performance Standards (NSPS) for SO_2 emissions from power plants were promulgated by EPA in December 1971. These standards apply to power plants for which construction or modification began after August 17, 1971. The standards limit the emission of SO_2 to 0.34 gram per million joules (0.8 lb per million Btu) when oil is burned and 0.52 gram per million joules (1.2 lb per million Btu) when coal is burned. These standards are equivalent to fuel sulfur contents of 0.7-0.8 percent and are roughly equivalent to 75 percent SO_2 removal from combustion off-gases of a typical coal- or oil-fired unit.

Sulfur Dioxide Control Technology

As a part of EPA's Office of Research and Development, the Control Systems Laboratory (CSL) at RTP has responsibility for the research, development, and demonstration functions required to assess and develop control technology for stationary sources to support the national air pollution prevention and control program mandated by the Congress. In response, CSL has established a comprehensive program to determine air pollution sources, assess the environmental impact of identified pollutants, and accelerate the development and commercial application of air pollution control technology. Approximately 80 percent of the CSL program to date has been devoted to the development of technology for the control of SO_2 emissions from stationary sources. (Under the recent reorganization within the Office of Research and Development, the Control Systems Laboratory has been reorganized into the Industrial Environmental Research Laboratory at RTP.)

The various options for sulfur dioxide control under investigation by the Laboratory include the use of clean (low-sulfur) fuels, coal gasification, coal liquefaction, advanced combustion processes, and flue gas desulfurization (FGD). These alternatives and their potential impact in meeting the 1975 sulfur dioxide control standards are compared in Table 1.

Based on a comparison of these SO_2 control technologies and a consideration of near-term (through 1980) needs, FGD is the only viable alternative – other than the burning of scarce, clean fuels – that is compatible with current regulatory requirements. Coal gasification, coal liquefaction, and advanced combustion processes are not expected to make a significant contribution until after 1985. Therefore, the continuing development and implementation of FGD technology remains an immediate concern of EPA and the Control Systems Laboratory.

FLUE GAS DESULFURIZATION

Flue gas desulfurization systems (scrubbers) are classified in two general categories (1) non-regenerable processes in which the sulfur-containing product is disposed of as waste and (2) regenerable processes in which the sulfur or sulfur-containing product is marketable.

The Control Systems Laboratory has provided engineering, economic, and evaluative support to the development, demonstration, and/or testing of the nine specific FGD installations summarized in Table 2.

CSL's efforts to develop and demonstrate FGD technology have contributed significantly to the availability of reliable technology for use in meeting air quality standards. The significance of these efforts is underlined by the widespread use of FGD systems throughout the United States. Twenty FGD systems with a total capacity of over 3300 MW are now operational. Twenty-two other systems, currently under construction, will control 7350 MW of electric generating capacity when completed, and another 40,000 MW of FGD capacity are in the planning stages. Thus, approximately 50,000 MW of FGD capacity are currently scheduled for operation by 1980.

Currently, most of the FGD installations in the operational, construction, and planning stages in the United States employ nonregenerable processes. Thirteen of the 20 FGD systems currently operational in the United States are lime or limestone based; 17 other such systems are under construction; and 41 systems are currently in the planning stages. The dominance of lime and limestone systems appears to be related to:

- The early start in development of these processes.
- The relative simplicity of the processes in terms of the number of process steps.
- The availability and widespread distribution of relatively cheap limestone.

Table 1. COMPARISON OF SULFUR DIOXIDE CONTROL ALTERNATIVES FOR STATIONARY SOURCES

Technology type	Potential applicability, % of total power plant fuel	Energy loss in process, %	Effective total cost of fuel[a] (Raw fuel and clean-up costs), mills/kWh	Year technology commercially available
Naturally clean fuels	50	0	Eastern coal 4.5-9.0[b] Western coal 4.0-6.0[b]	Current
Flue gas desulfurization	85	6	6.0-10.5	Current
High-Btu coal gasification	0	30	12+	1980-1985
Coal liquefaction	0	30	6.6-9.6	1980-1985
Fluid bed combustion of coal	15	2	3.3-8.4	1977-1978
Chemical coal cleaning	35	10	4.7-8.3	1977-1978
Low-Btu coal combustion	10	20	8.3-12.8	1977-1983

[a]These costs were developed in late 1974 and do not reflect changes in costs of fuel and materials since that time; however, the data do allow valid relative comparisons.

[b]Costs are for delivery to plants in region where coal was mined.

- The presence of many lime and limestone system vendors.
- The lower cost of lime and limestone systems utilizing simple disposal in comparison with regenerable processes, which face an uncertain by-product market.

For regenerable processes, three systems are operational, three are under construction, and seven are in the planning stage. With the exception of one system under construction, all the systems in the latter two categories reflect decisions made within the last year. This accelerated rate of development and application of regenerable processes is expected to continue based on:

- The conservation of natural resources—land is not needed for sludge disposal and sulfur products with societal and market benefits are produced.
- The conservation of energy—centralized regeneration will not only reduce process costs due to economy of scale but will also save energy due to more efficient, large, base load design.
- The greater emphasis on land use planning.
- The preponderance of second generation regenerable processes compared with nonregenerable processes in this category.
- The availability of process packages consisting of a process developer, process operator, and by-product using and marketing organizations for commercial application.
- The effect of inflation on regenerable process costs compared with nonregenerable process costs.

ISSUES

The proliferation in plants using FGD as a means of sulfur dioxide control is occurring despite a number of past and current differences of opinion and heated debate between EPA, other Federal agencies, and the utility industry. How reliable are scrubbers? How much do they cost? Who pays for them? Do they create additional pollution? Are they really necessary? What effect do they have on the energy situation? These are some of the questions that are being asked about FGD. Some of the answers are now available, others are in sight, and still others are being sought. Answers to some of these questions are presented in the following paragraphs.

Availability and Reliability — A CSL survey to determine the status of FGD technology in the

Table 2. EPA-SUPPORTED FLUE GAS DESULFRUIZATION PROCESSES

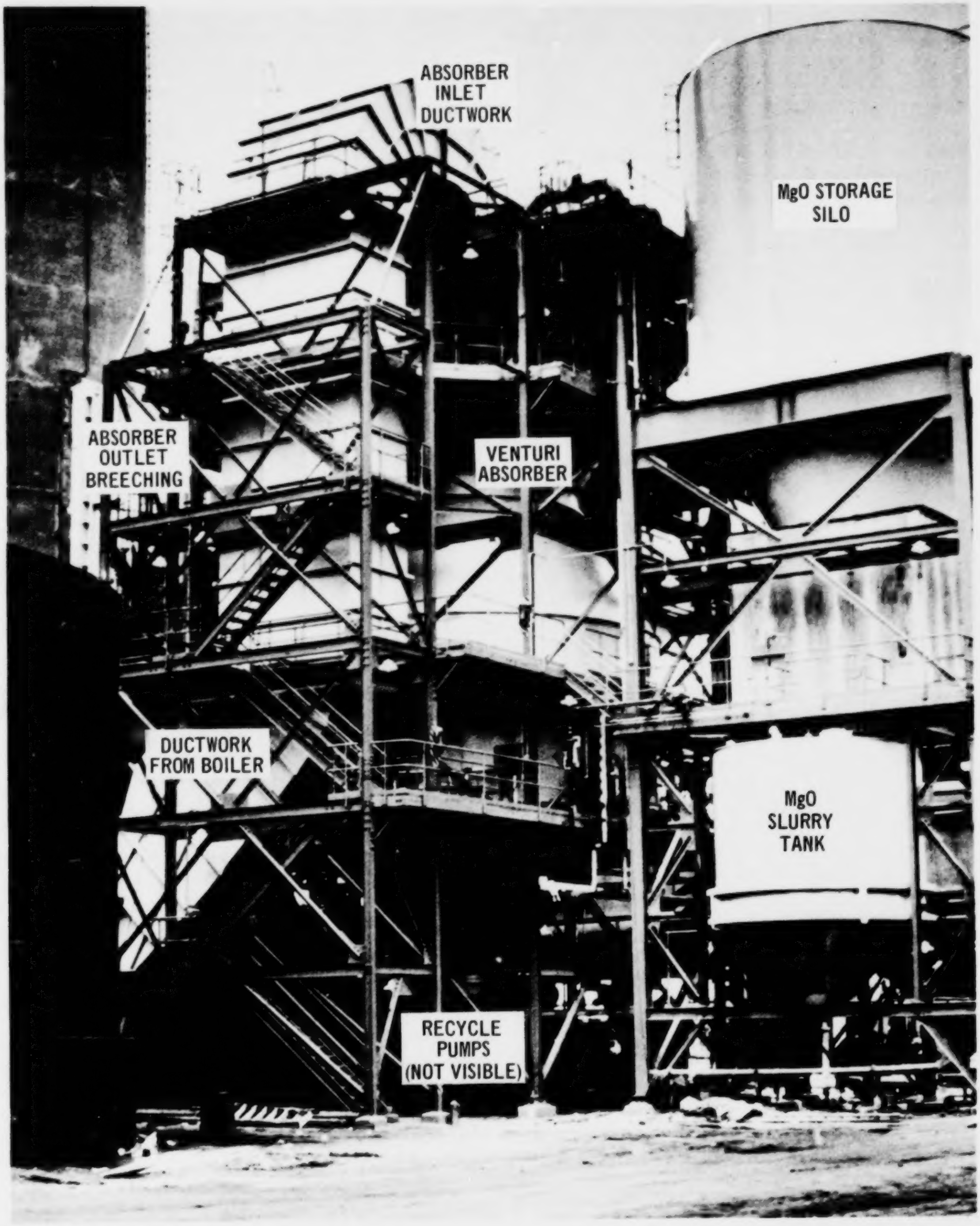
Process	Waste/by-product	Application	SO_2 removal efficiency, %
Wet lime/limestone scrubbing	Throwaway sludge	30-MW (prototype) coal-fired utility	75-90
Wet lime scrubbing	Throwaway sludge	40-MW (full-scale) oil-fired utility	60-80
Wet lime scrubbing	Throwaway sludge	24-MW (full-scale) coal-fired industrial	80-90
Magnesium oxide	98% Sulfuric acid	155-MW (full-scale) oil-fired utility	85-90
Magnesium oxide	98% Sulfuric acid	100-MW (full-scale) coal-fired utility	85-90
Catalytic oxidation	78% Sulfuric acid	100-MW (full-scale) coal-fired utility	85-90
Wellman-Lord/Allied	99% Elemental sulfur	115-MW (full-scale) coal-fired utility	90-95
Double alkali	Throwaway sludge	30-MW (full-scale) coal-fired industrial	85-95
Double alkali	Throwaway sludge	20-MW (prototype) coal-fired utility	85-95

United States was initiated in April 1974. Survey results indicated that most plants have achieved control of process chemistry and scaling; however, many units are still involved in solving mechanical problems such as frozen venturi throat drives, fan vibration, and erosion.

The survey further indicated that the availability and reliability of FGD systems is a major concern but that significant improvement has been achieved as indicated by the recent, almost flawless operation of the limestone scrubber system at Commonwealth Edison's Will County (Illinois) Station. This system, plagued with operational problems and a power production availability record in the 30 percent range over the first 23 months of its existence, achieved an average availability greater than 90 percent for a 12-month period beginning in July 1974. For the last 6 months of this period, the average availability was in excess of 98 percent. Proponents of FGD for SO_2 emission control can now point to this system as a showcase example of the capability of FGD to achieve the intended goals.

Cost — The ultimate cost of commercial-scale FGD systems for coal-fired utility power plants is a complex and controversial subject. Published cost estimates range from the unrealistically low to the ridiculously high. The most comprehensive and detailed cost study available is the Tennessee Valley Authority five-process study reported in November 1974. This study pegged FGD capital costs between approximately $40 and $80/kW for typical coal-fired applications. Corresponding annualized costs were 2.5 to 5.0 mills/kWh. Because these cost determinations were made prior to the remarkable escalation of equipment and construction costs that took place in 1974 and in 1975, adjustment of 25 to 30 percent is required to bring these costs up to current dollars. Realistically, FGD costs for large-scale (500-1000 MW) plants should range from $60 to $100/kW with annualized costs of 3.0 to 6.0 mills/kWh. The annualized costs of FGD use on a commercial basis is approximately 0.28 to 0.56 mills per million joules (30 to 60 cents per million Btu) of fuel cost differential.

Funding Approach — The answer to this problem, unfortunately, is one of the major deterrents to the installation of FGD systems. Many utilities that have been able to negotiate contracts for low-sulfur fuels


ABSORBER INLET DUCTWORK
MgO STORAGE SILO
ABSORBER OUTLET BREECHING
VENTURI ABSORBER
DUCTWORK FROM BOILER
MgO SLURRY TANK
RECYCLE PUMPS (NOT VISIBLE)

EPA/Boston Edison demonstration of magnesium oxide process for cleaning flue gas.

are allowed to pass most of the increased costs for the low-sulfur fuels directly and immediately to the consumer without regulatory commission action. On the other hand, utilities must apply for rate increases to cover the capital and operating expenses for FGD systems. It would appear reasonable and desirable to pass FGD system costs directly to the consumer in the same manner as increased costs for low-sulfur fuels are handled, and EPA has requested that all state utility commissions consider this approach to funding the construction and operation of FGD systems. There is evidence of increasing public support for such an approach in a recent Harris Poll showing that the percentage of people in favor of paying some pollution control costs had increased from 34 to 46 percent in the 2-year period from 1973 to 1975.

Additional Pollution – The major issue here has been the large quantities of waste material (sludge) produced by nonregenerable FGD processes. A comprehensive research and development program, under CSL sponsorship, is currently underway to characterize FGD sludges and to develop and assess disposal and utilization methods. Based on available information, the best methods currently available for sludge disposal are landfilling of chemically fixed sludge or disposal of untreated sludge in ponds lined with an impervious material such as clay, plastic, or rubber. Alternate methods, including coal mine and ocean disposal, are currently under study. Another major alternative is FGD sludge utilization; for example, limited markets are expected in the wallboard and Portland cement industries for gypsum produced from FGD sludge. Technology also exists for the utilization of scrubber sludge in products such as mineral wood, bricks, road base materials, artificial aggregate, and aerated concrete. Other uses for FGD sludge, such as filler material in fertilizers, are currently being studied. Because of uncertainties in marketing FGD by-products, however, most of the FGD sludge produced, at least in the short term, will be discarded. For this reason, and because disposal presents a potential for adverse environmental effects, the major thrust of the CSL sludge program has been concerned with disposal.

In recent months, evidence indicating the potentially harmful effects of sulfate species in the atmosphere has focused attention on FGD systems as potential emitters of sulfates. Although the possibility of the emission of sulfates from FGD system exists, the essential question of comparative quantities and characteristics of sulfates emitted from controlled and uncontrolled sources must be addressed. An uncontrolled source emits 100 percent of the sulfuric acid mist formed in the boiler; such a source also emits 100 percent of the SO_2 formed in the boiler, and the potential for subsequent atmospheric conversion of the emitted SO_2 to sulfates must be considered. An FGD system will remove approximately 50 percent of the sulfuric acid mist and 90 percent of the SO_2 that would be emitted to the atmosphere from an uncontrolled source; thus, actual and potential sulfate emissions from a controlled source are significantly reduced.

The potential emission of small quantities of relatively innocuous sulfate compounds, such as calcium, magnesium, and sodium sulfates that are produced in the SO_2 scrubbing reactions is of little consequence in comparison to the benefits attained.

Need for FGD – Flue gas desulfurization systems are consumers of resources, energy, and capital. They do not generate electricity, but they do generate materials that must either be sold or disposed of in an environmentally acceptable manner. FGD must, however, be viewed in light of the alternatives. There is currently sufficient evidence to conclude that direct-firing of relatively high sulfur coal will play an increasing role in the generation of electricity through the 1980's and possibly well into the 1990's. Many indicators – including the continued delays, technical problems, and escalating costs associated with nuclear power; the extremely high costs and low energy efficiency of coal gasification as highlighted by recent TVA and Commonwealth Edison studies; the projected high costs and early state of development of solvent refining and liquefaction; and the scarcity, transportation expense, and applicability of western low-sulfur coals – all point to continued reliance on conventional coal-firing as a mainstay in electrical utility expansion plans. With dramatic increases in the use of high-sulfur coal a near certainty, particularly in the eastern half of the country, the widespread use of FGD will be necessary to maintain atmospheric loadings and groundlevel air quality at their present levels, let alone achieve the ultimate goal of the Clean Air Act, the enhancement of air quality.

Energy Usage – FGD systems will allow the use of our most abundant energy resource – high-sulfur coal – while providing protection from the sulfur oxides produced when the coal is burned. The comparatively small energy penalty (4 to 7 percent) associated with the use of FGD is a reasonable price to pay when the alternatives and the benefits are considered.

CSL Research – The Control Systems Laboratory is involved in a comprehensive program that has provided some of the answers to the issues surrounding the FGD process and is actively seeking the answers to the remaining questions. The CSL program includes:

- The assessment of environmental/health effects of pollutants such as sulfate species.
- The support of two additional demonstrations of FGD technology at the 100-MW scale.

- A study of sludge disposal techniques and sludge marketability.
- Studies of the market for the by-products of regenerable FGD systems.
- A survey of non-utility source contributions to ambient sulfur dioxide concentrations.
- Studies directed toward the production of elemental sulfur by second generation FGD systems to reduce the quantity of by-products produced and to facilitate storage and shipment.

In addition to these and other activities, CSL may initiate a regenerable process demonstration on an industrial boiler that fires a mixture of fossil fuels and municipal wastes. High priority has been assigned to a comprehensive information transfer program that will be designed to maximize the dissemination and implementation of FGD technology information. One facet of the information transfer program will be the development of a FGD system for installation at a specific location having specific requirements. The model will provide one-source availability of pertinent FGD data and information and will permit informed decision making that should result in earlier operation of the FGD systems.

FGD's FUTURE

As a result of critical national energy and economic needs, the Clean Air Act is being reevaluated and may be amended. Proponents of intermittent control procedures and the use of tall stacks for sulfur dioxide dispersion, as well as those who favor permanent control by FGD, are making their opinions known to the Congressional committees responsible for evaluating the Act and making recommendations to the Congress.

The use of intermittent controls and tall stacks by electric utilities has been a source of debate and controversy over the last several years. To qualify for the use of intermittent controls, a plant would have to be the sole or major source of sulfur oxides and thus be responsible for the sulfur dioxide pollution within the particular area. The effectiveness of intermittent controls depends on the utilities' willingness to regulate their own operation as required by meteorological conditions; for example, when a weather condition such as a thermal inversion occurs, a utility would either shut down the plant in the affected region or switch to reserves of low-sulfur coal. The question, however, of what would be done with the high-sulfur coal already in a bunker when an adverse meteorological condition develops has yet to be adequately addressed.

Tall stacks, in most cases, allow compliance with present ambient air standards because they disperse the pollutants into the atmosphere and reduce groundlevel concentrations. Many utility representatives, as well as some representatives of the Federal Power Commission and the Tennessee Valley Authority, have maintained that these methods are compatible with the Clean Air Act requirements for meeting ambient air quality standards. Concern about the adverse health effects of sulfates formed primarily by conversion of sulfur dioxide in the atmosphere, however, argues against the use of these methods and could, in fact, lead to even tighter ambient air quality limits for sulfur dioxide. Recent court decisions have supported EPA's contention that dispersion and dilution are inadequate means for dealing with the increasing sulfur dioxide emission problem and that the only adequate control methods are emission limitation techniques.

A key proposal in the Administration's proposed amendment to the Clean Air Act is permission for EPA to extend the 1975 compliance deadline for selected power plants to 1985. To qualify for this 10-year delay, a plant would have to be located in an isolated area and use an intermittent control system.

The result of Congressional deliberation is likely to be a reasonable compromise between the two divergent positions. The EPA Administrator has pledged the Agency's willingness to support an Energy Resource Council proposal to extend the deadline for implementation of permanent controls, with the qualification that ambient air quality standards be met in the interim. The proposal would require (1) that violating power plants sign compliance schedules for installing permanent controls and (2) that compliance with state emission standards be delayed until the FGD systems are operational.

Senator Edmund S. Muskie, Chairman of the Subcommittee on Environmental Pollution, has indicated that intermittent controls and tall stacks only disperse pollution and are not enforceable. He has further stated, "We must reweave the fabric of the Clean Air Act to keep deadlines and yet permit flexibility when good faith has been demonstrated. Perhaps we'll have to supplement these deadlines with statutory penalties triggered when deadlines are breached and good faith has not been demonstrated."

So, although debate may continue and although Congress may modify the Clean Air Act, it seems apparent that there will be significant application of FGD systems to power plants for control of sulfur dioxide emissions between now and 1985. In fact, a careful examination of the alternatives – keeping in mind the costs, problems, and limitations to each – indicates that FGD systems will probably be operating to lessen the environmental impact of the use of our plentiful coal resources for the remainder of this century and beyond.

Automotive Oxidation Catalyst

On March 5, 1975, the Administrator of the Environmental Protection Agency announced his decision to grant suspension of 1977 motor vehicle exhaust emission standards for one year. At the same time, he recommended to Congress that the 1975 national interim standards for hydrocarbons and carbon monoxide be retained for the 1978 and 1979 model year and that emission standards at the interim California levels for the two pollutants be established for model years 1980 and 1981. He further announced his intention to establish an emission standard for sulfuric acid, applicable to 1979 and subsequent model years.

In making this decision, EPA Administrator Russell Train stated that were it not for his belief that the weight of scientific opinion indicates a legitimate cause for concern that sulfuric acid emissions from the catalytic converter represent a risk to public health, he would not have granted the suspension. (Automobile emission standards before, during, and after the suspension are shown in Table 3.)

The level of the suggested sulfuric acid standard is as yet to be determined. In balancing the emission levels permissible for sulfuric acid and for hydrocarbon and carbon monoxide, the Administrator emphasized that two objectives must be reconciled: preventing an increase in automotive sulfuric acid emissions in excess of currently projected levels and preserving, as much as possible, the momentum EPA has built up toward achieving further reductions of hydrocarbon and carbon monoxide emissions from the automobile.

Administrator Train pointed out that the decision as to the level for the sulfuric acid standard will be a very difficult one. "Unfortunately," he said, "data are not now available and probably will still be unavailable at the time that an emission limit must be established for sulfuric acid for 1979 model year vehicles, to determine the level of sulfuric acid emissions that could confidently be considered acceptable from a public health standpoint."

The suspension decision and the related long-term recommendation as announced by the Administrator were a direct consequence of the results of the first full year of EPA's catalyst research program, directed as part of ORD-RTP's Fuels and Fuel Additive Registration Program. (Under the recent reorganization within the Office of Research and Development, the catalyst research program has been incorporated into the Health Effects Research Laboratory at RTP.)

Table 3. AUTOMOBILE EMISSION STANDARDS BEFORE, DURING, AND AFTER ONE-YEAR SUSPENSION OF 1977 STANDARDS ANNOUNCED BY EPA ADMINISTRATOR
(grams per mile)

Status of standards and model year	Pollutant[a]			
	HC	CO	NO_x	H_2SO_4
Standards in effect before March 5, 1975				
1975-1976				
United States except California	1.5	15	3.1	-
California	0.9	9	2.0	-
1977	0.41	3.4	2.0	-
1978	0.41	3.4	0.4	-
Standards during 1-year suspension				
1977				
United States except California[b]	1.5	15	2.0	-
1978				
United States except California[b]	0.41	3.4	0.4	-
Standards recommended after 1-year suspension				
1977				
United States except California[b]	1.5	15	2.0	-
1978-1979	1.5	15	2.0	0.001 - 0.010
1980-1981	0.9	9	2.0	0.001 - 0.010
1982	0.41	3.4	2.0	0.001 - 0.010

[a] HC = hydrocarbons, CO = carbon monoxide, NO_x = nitrogen oxides, H_2SO_4 = sulfuric acid.

[b] Standards to be determined by State action.

ORD-RTP has conducted its Fuel Additive Registration program since FY 1971. The impetus for expansion of that program to include a study of the health impact of the automotive oxidation catalyst can be traced to the passage of the Clean Air Act of 1970.

Section 202 of the Clean Air of 1970, as amended, mandated substantial reductions in certain specified emission products from automobiles. The automobile industry, to achieve this reduction, chose the oxidation catalytic converter as a primary method of emission control for model year 1975. After this decision was made known to EPA, the Agency intensified its research program to determine what, if any, new pollutants might be emitted into the atmosphere as a result of the application of this technology. Also studied were the effects of fuel composition and fuel additives on these new pollutants as well as the regulated pollutants. The EPA research program results indicated that, although emissions of hydrocarbons, carbon monoxide, and certain organics would be dramatically lowered, sulfuric acid aerosol emissions would increase, and that slight emissions of platinum, palladium, and alumina might also be expected.

Because existing ambient concentrations of sulfates in many areas of the country have been shown to be at levels sufficient to cause concern to those in EPA and elsewhere responsible for the protection of public health and because little information existed regarding health effects of platinum or palladium as air pollutants, EPA initiated a broad research program to examine the questions of public health impact of these three pollutants: catalyst-emitted sulfates, platinum, and palladium.

In testimony to the Public Works Committee of the U.S. Senate in November 1973, the EPA Administrator specified EPA's planned program of catalyst-related research:

- Accelerate work on development of a reliable test procedure for automotive sulfate emission measurement.
- Consider all feasible alternatives for automotive sulfate emission control.
- Improve the Agency's ability to estimate the public health impact of sulfate and other automotive emissions.
- Improve understanding of the atmospheric chemistry involved in these emissions and initiate an appropriate air monitoring program.

From these broad objectives outlined in the Administrator's testimony of November 1973, an extensive interdisciplinary research program was developed. The program utilizes the resources of a broad range of EPA's technical staff from both the Office of Research and Development and the Office of Air and Waste Management and the resources of the scientific community outside the government through extramural programs.

The strategy underlying the establishment of the program can briefly be summarized in the following six objectives: (1) identify emissions, (2) determine emission levels, (3) estimate human exposure, (4) assess public health impact of exposure, (5) evaluate the available control options, and (6) provide timely reports to provide a basis for management decisions.

Within this framework, the resources available both within EPA and in the research community were marshalled to address the issue in the following areas:

- Emissions characterization.
- Emission measurement methodology development.
- Meteorological modeling.
- Toxicology (classical and inhalation).
- Human health studies (epidemiology, occupational, exposure).
- Control technology.

Because each of these areas of expertise impinges upon one or more of the others, clear definition of objectives and methods, centralized program direction, and close coordination were needed from the beginning of the program. Because the program cut across traditional organization structures, a matrix approach emerged as the appropriate management tool for effective use of disparate and diverse resources, both human and financial.

Technical conclusions based upon results of the program to date can be summarized as follows:

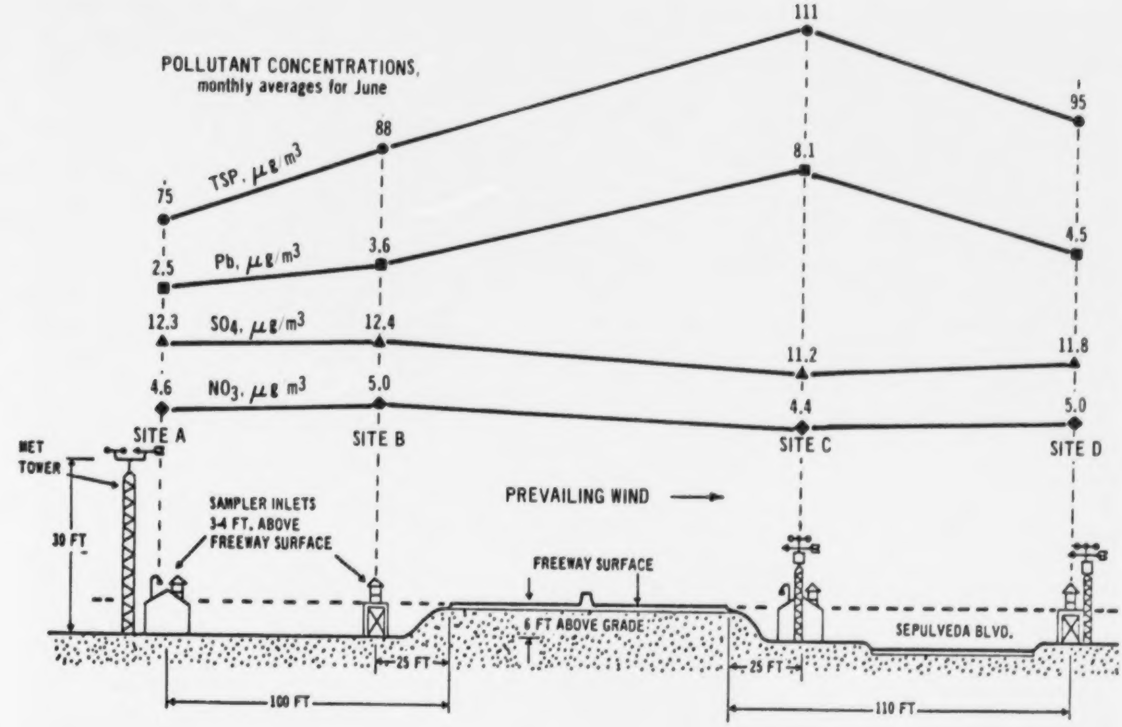
- The current (1974 model year and older) in-use light-duty motor vehicle population emits trace quantities of sulfuric acid.
- The current ambient sulfate particulate levels reported by epidemiological studies (CHESS) already exceed the estimated health effects threshold on many days of the year in many urban centers, particularly in the northeastern United States.
- Oxidation catalyst-equipped, light-duty motor vehicles emit sulfuric acid aerosol. Although non-catalyst-equipped vehicles appear to convert about 1 percent of fuel sulfur to sulfuric acid, catalyst cars convert 20 to 40 percent of such sulfur to sulfuric acid, with air-injected catalyst-equipped vehicles being the higher emitters.
- Catalyst-generated sulfuric acid aerosol will result in localized incremental exposures to persons on and near major highways and other areas of high motor vehicle densities.
- The catalyst-generated localized, incremental sulfuric acid exposure is projected to exceed the estimated health effects threshold after 2 model years of vehicles are equipped with catalysts in California and after 3 to 4 years in the rest of the nation. Such exposures would occur on and near our busiest highways.
- Development of a reliable analytical measurement method specific to ambient sulfuric acid is crucial, because no such method now exists. The wet chemical techniques for ambient particulate sulfate are not necessarily specific for sulfates because sulfides and sulfites, if present, will interfere. Thus, the present techniques only measure total particulate water-soluble sulfur compounds.
- Existing (pre-catalyst) baseline data establishing current rural, urban, and occupationally exposed human burdens of platinum and palladium need to be clearly defined and are under investigation.
- Research on long-term health effects of platinum, palladium, and sulfuric acid must be continued.
- Methods to control sulfuric acid emissions from catalyst-equipped vehicles must be pursued.
- Preliminary pre-catalyst baseline studies on the Los Angeles freeway monitoring site tend to confirm – via carbon monoxide, lead, and sulfur dioxide surrogates – the projected incremental sulfuric acid exposures.

A full discussion of the results of the catalyst research program through January 1975 was presented in two EPA publications: *Issue Paper –*

Because of their high traffic volume, freeways in the Los Angeles area provide good study sites for assessing emissions from the automotive oxidation catalyst.

Estimated Public Health Impact as a Result of Equipping Light-duty Motor Vehicles with Oxidation Catalysts, and *Estimates of the Public Health Benefits and Risks Attributable to Equipping Light-duty Motor Vehicles with Oxidation Catalysts.* The Administrator, in discussing these papers as part of the basis for his March 5 decision, characterized them as providing "as good an estimate of the problem as can be made at this time given the tremendous uncertainties of this matter. Future studies of this issue are necessary and are being undertaken."

Priority areas to be studied as part of the continuing catalyst research program include: development of a stronger data base in health effects of sulfuric acid, development of a reliable ambient sulfuric acid measurement technique, establishment of definitive emission factors and sulfur conversion rates for current model year automobiles, and further validation of models used to determine exposure estimates.



Pollutant concentrations adjacent to the freeway vary with distance and meteorological factors.

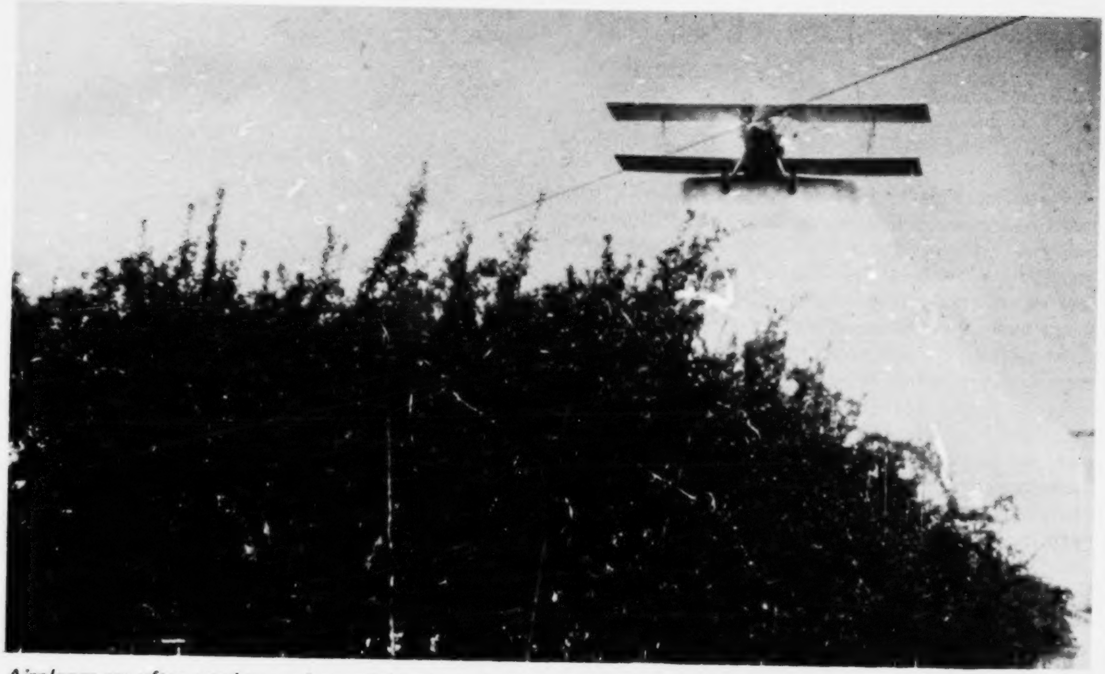
Pesticides and the Environment

Pesticides have brought tremendous benefits to mankind by controlling the vectors of serious human and animal diseases and by greatly increasing yields of many crops. The need for food will likely increase as the world's population increases; consequently, it seems likely that the use of pesticides will expand for some years to come. Unfortunately, adverse environmental effects and possible toxic effects to humans can arise from pesticide usage. Residues of persistent pesticides have been found in air, soil, plants, rivers and oceans, fish, birds, mammals, and even humans. The accumulation of pesticide residues in the environment has concerned the scientific community and has been the subject of intensive research and monitoring activities. Research efforts are currently focused on assessing the effects of long-term, low-level pesticide exposure on the human population; identifying potentially toxic impurities in pesticide formulations; and developing rapid toxicological screening tests to detect early exposure to harmful pesticide residues before adverse clinical effects become manifest.

The Environmental Protection Agency has a legislative mandate to control pesticide usage under the Federal Insecticides, Fungicide, and Rodenticide Act, which was amended in 1972 as the Federal Environmental Pesticide Control Act (FEPCA). Under FEPCA, the Agency has regulatory authority ranging from requirements for pesticide use information on product labels to protection of human health through monitoring and research activities. Under this legislation, EPA placed a near total ban on the use of DDT in 1972, suspended the manufacture of aldrin and dieldrin, and began legal hearings to institute limitations on the use of heptachlor, chlordane, and their metabolite, heptachlor epoxide.

PESTICIDE CYCLE

Before 1974, organic materials of natural origin, such as pyrethrum and rotenone, were often used as pesticides. Inorganic compounds such as arsenicals, hydrogen cyanide, and heavy metal salts also came into early use. Shortly before World War II, however, synthetic organic pesticides, the most well-known of which was DDT, came into limited use. After DDT came into wide use, the appearance of insects that had developed resistance to this compound led to the active search for new pesticides. Today in the United States, there are over 900 active pesticidal chemicals formulated into more than 60,000 preparations used



Airplanes are often used to apply pesticides in orchards.

as insecticides, fungicides, herbicides, and plant growth regulators.

Most insecticides in current or recent use are chemically classified as chlorinated hydrocarbons, organophosphates, or carbamates. The chlorinated hydrocarbons represent the most persistent types of compounds the residues of which can have a long residence time in the environment; they poison insects through surface contact or stomach action. The most familiar compounds in the chlorinated hydrocarbon series include DDT, aldrin, dieldrin, endrin, toxaphene, heptachlor, chlordane, and lindane. Organophosphate compounds are characterized as less persistent than the chlorinated hydrocarbons and act as inhibitors of the enzyme cholinesterase. Examples of organophosphate pesticides include malathion, parathion, DDVP, Guthion, and diazinon. The carbamate insecticides are of comparatively recent development and apparently act in a similar fashion to the organophosphate compounds, that is, by inhibition of cholinesterase. The carbamates, which are rapidly detoxified and eliminated from animal tissue, exhibit minimal bio-accumulation. Examples include carbaryl, carbofuran, methomyl, and Baygon.

Herbicides are chemically derived from inorganic acids, metal organic compounds, carboxylic aromatic compounds, aliphatic acids, substituted phenols, and heterocyclic and aliphatic organic nitrogen compounds. Examples of herbicides include 2, 4-D, 2, 4, 5-T, Silvex, Carbyne, and atrazine. Fungicides and bactericides are usually formulated from inorganic compounds such as copper sulfate and mercuric chloride and from dithiocarbamates such as ziran, maneb, and ferbam.

Pesticides are usually applied to crops or specific vectors by air or ground application as aerosol sprays or volatilized gases. In one sense, this is the only case in which man deliberately "pollutes" the environment with potentially toxic compounds that can have wide ranging effects. Environmental transport processes can distribute pesticides widely in air, soil, and water and can lead to the accumulation of residues in the biosphere. Airborne pesticide particles can be transported by wind currents; adsorbed on other airborne particles; photodecomposed into potentially more toxic residues; and removed from the atmosphere by sedimentation, impaction, and scavening processes such as rainfall. The predominant factor in the transport of airborne pesticide sprays is the particle size of the aerosol: finer particles exhibit a longer residence time in the atmosphere than coarse particles. Pesticides applied to the soil can evaporate back into the atmosphere as a gas; degrade by microbiological, chemical or photochemical action; accumulate in soil, crops, and animals, and subsequently in man; and be transported to the hydrosphere by runoff and leaching processes. Pesticide residues introduced into the hydrosphere can undergo chemical decomposition and biodegradation; evaporation into the atmosphere; and accumulation in plankton, fish, and eventually man.

The inevitable end point in the pesticide cycle is man. However, much is still unknown in all areas of the pesticide cycle including the process of environmental transport, the mechanisms of partitioning among environmental components – that is, atmosphere, lithosphere (soil), hydrosphere, and biosphere – and the effect of photochemical reactions, microbiological attack, chemical decomposition, and other reactions on the fate of pesticides.

TOXIC EFFECTS

Most of the available information concerning the toxicity of pesticides has been derived from studies with experimental animals and from human poisoning cases, primarily through occupational exposure. A correlation has been demonstrated between acute toxocity levels of many pesticides in experimental animals and human poisoning experiences. The predominant routes of exposure for man are through inhalation and from oral and dermal contact; however, toxic effects, regardless of the exposure route, are associated with the physiological action of the classes of compounds as well as the dosage received. Pesticide poisoning is further complicated by the fact that metabolic action in the body can often result in the production of residues that are even more toxic than the original compound.

The major effect of the chlorinated hydrocarbons is on the central nervous system with minor changes produced in the liver (especially in rodents) and to a lesser degree in other organs. In fatal poisonings, a fine tremor appears followed by progressive involvement of the neuromuscular system; death may result from ventricular fibrillation. Most of these chlorinated hydrocarbons accumulate in body fat to the extent that illness in experimental animals has been demonstrated by repeated exposure.

The organophosphate pesticides appear to act primarily through inhibition of the enzyme cholinesterase. Poisoning symptoms are associated with overstimulation of the parasympathetic nervous system. The carbamate pesticides also act by inhibiting cholinesterase; however, unlike the organophosphates, they are competitive rather than irreversible inhibitors of this enzyme. The organophosphates and carbamate insecticides are much less persistent in the environment and in the animal body than are the chlorinated hydrocarbons. Their effects on cholinesterase inhibition may be cumulative despite their low storage potential.

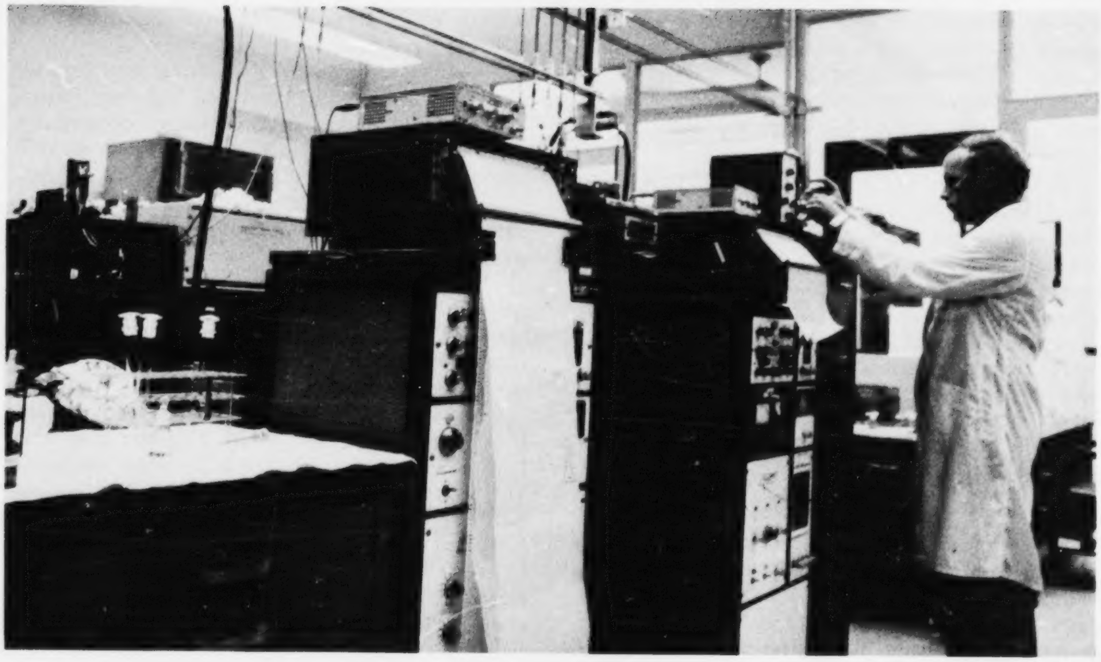
Other factors play a role in determining the toxicity of pesticides to a particular organism. Among these are age; sex; nutrition; disease; temperature; route of exposure; interaction of the pesticide with chemicals, drugs, and other pesticides; type of pesticide formulation; and photochemical effects. Assessing pesticide toxicity through the use of experimental animals is further complicated by the fact that different animal species can exhibit different responses to the same compound. Extrapolation of effects derived from animal studies to effects in humans is difficult and can be misleading if metabolic pathways are significantly different.

Perhaps most disturbing are the mutagenic, teratogenic, and carcinogenic effects that may arise from long-term, low-level exposures to these chemicals. Test methods presently available are not entirely satisfactory for assessing these special toxicity factors. Based on present information, no firm conclusions can be made as to whether pesticides represent a mutagenic hazard to humans. On the other hand, a number of pesticides have been implicated as possible teratogens and include 2, 4, 5-T; captan; carbaryl; certain esters of 2, 4-D; PCNB; and some mercury compounds. Possible carcinogenic effects have been associated with DDT, aldrin, dieldrin, mirex, heptachlor, and other compounds, many of which are banned from use by EPA.

CANCELLATION PROCEEDINGS

Under the legislative authority provided by FEPCA, the Environmental Protection Agency can ban the use of a pesticide if its use would pose an unacceptable risk to man and the environment. The Pesticides and Toxic Substances Effects Laboratory (PTSEL) at ORD-RTP has made many scientific contributions toward assessing the environmental threat from pesticides. (Under the recent reorganization by the Office of Research and Development, Pesticides and Toxic Substances Effects Laboratory has been incorporated into the Health Effects Research Laboratory at RTP.)

Pesticides research has led to a near total ban on the use of DDT and the suspension of the manufacture of aldrin and dieldrin. More recently, PTSEL has provided health effects research data for use in pending cancellation hearings on Mirex and 2, 4, 5-T. The Administrator of EPA has also announced his intention to ban the use of heptachlor and chlordane on certain food crops and on lawns and gardens. In considering the cancellation of a registered pesticide, the availability of alternate registered pesticides is vitally important.



Gas-liquid chromatography is used to analyze pesticide residue.

CURRENT RESEARCH

Research is carried out at ORD-RTP to assess the effect of pesticides on the environment. Most efforts are focused on toxicity studies using animal model systems, field studies to address "real world" exposure problems, and analytical methods development to improve sensitivity and specificity of residue analysis in various environmental media. Development of new chemical and biological pesticides by industry and the recognition of previously unknown hazards associated with pesticides in current use will continue to require new knowledge of pesticide toxicology and chemistry.

Toxic Impurities

With the discovery of the toxic contaminant 2, 3, 7, 8-tetrachloro-dibenzo-p-dioxin (TCDD) in formulations of the herbicide, 2, 4, 5-T, active research began to detect and identify other potentially toxic contaminants in commercial formulations. During the chemical synthesis of pesticide compounds, the possibility that unwanted toxic products may also be cosynthesized or carried through manufacture from the initial starting materials is a distinct possibility. Both theoretical studies of synthesis processes and laboratory analysis of typical pesticide compounds are underway to prevent future release of potentially toxic materials into the environment.

Insect Pathogens

Technology has developed new generations of pesticides that use more effective chemical formulations, techniques for controlled release through microencapsulation, and biological insect control agents such as insect pathogens and synthetic juvenile hormones. Toxicological research is underway with the newly developed viral insect pathogens to ascertain whether adverse acute or chronic effects can be associated with their use. Of immediate interest is to determine whether mutations potentially harmful to man or the environment could arise from long-term use of these agents.

RAPID SCREENING TESTS

The search for methods of detecting early exposure to pesticides before actual symptoms of poisoning are evident has been underway for many years. Two EPA-developed techniques that show promise are a chemical method for detecting organically bound phosphate residues in urine after exposure to organophosphate pesticides and a neurophysiological method to detect subtle changes in brain-wave patterns after pesticide exposure. Other tests based on bioassay methods to rapidly screen pesticidal compounds and to identify specific toxic effects associated with exposure to them are under development. For example, the chick embryo is under study as a bioindicator for dioxins and various pesticide compounds.

CHEMICAL METHODOLOGY

Gas-liquid chromatography (GLC) has been widely used for detecting pesticide residues since the 1960's. More recent developments have been made to improve GLC separation columns and detectors to increase sensitivity and improve specificity. Present development efforts involve the use of high resolution mass spectrometry and nuclear magnetic resonance methods for quantitation and confirmation. Active research is underway to develop comprehensive multi-residue methodology for detecting simultaneously numerous classes of pesticidal compounds.

ROUTES OF EXPOSURE

Research on the routes of pesticide exposure is on-going at EPA to determine the absorption and, therefore, the toxicity of residues. Usually pesticides are more toxic by the oral route than by the dermal route; however, the available data on inhalation exposure is too meager to make definitive comparisons. Studies are underway at ORD-RTP to assess the hazard associated with the inhalation mode of exposure utilizing animal model systems. Emphasis is placed on expanding the inhalation toxicology program, especially in determining tissue residue levels from acute exposures.

Buildings and the Environment

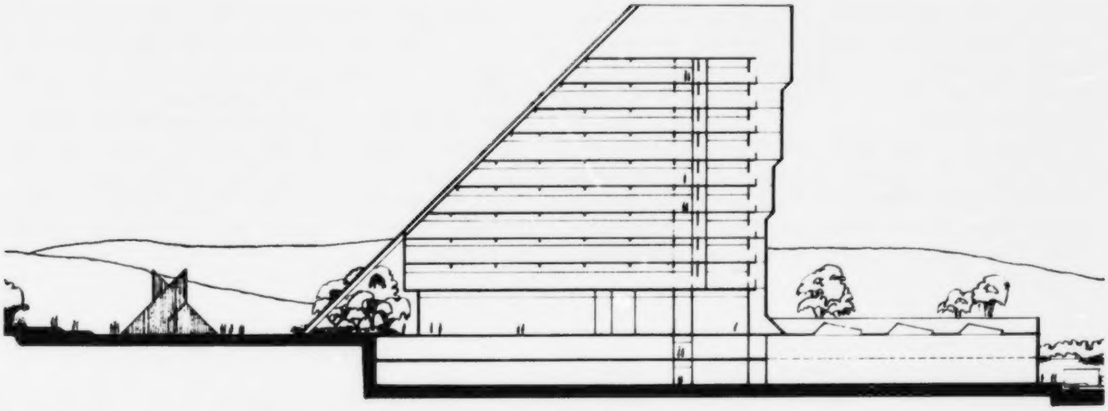
The control of air pollution and the reduction of fossil fuel consumption are areas of growing concern in the United States. In 1972, the combustion of fossil fuel to meet energy needs was responsible for the emission to the atmosphere of 77 percent of all sulfur oxides, 51 percent of all nitrogen oxides, and 40 percent of all particulate matter. The demand for energy will triple by the year 2000; a comparable growth in pollution levels is expected to accompany this increase. Simultaneously, increasing shortages of fossil fuels are emphasizing the need to conserve limited energy resources. Examination of the interrelating problems of air pollution control and energy conservation has led to a viable, single solution: reduce fossil fuel consumption through the application of energy-conserving and non-polluting methods of energy use.

The most readily available opportunity for application of this solution is in the design of buildings. Energy consumption for space heating, water heating, and air conditioning in buildings represents 33 percent of the nation's energy budget exclusive of transportation. A decrease in consumption by this sector would contribute much needed relief to the energy shortage and would significantly decrease pollutant levels.

ORD-RTP is charged by EPA with developing methods to control air pollution. Accepting the correlation between energy supply and environmental degradation and the relief of some environmental problems achieved through energy conservation, researchers at ORD-RTP applied the conservation-protection concept to a large-scale study.

The study, which included an exploration of the energy conservation techniques and alternate energy supply technologies currently or soon-to-be available, resulted in the design of an energy-efficient facility, in which ORD-RTP research activities could be conducted. The self-contained prototype structure, which is essentially non-polluting, answers the needs of the ORD-RTP operation, achieves a 40 percent energy savings, and costs no more than a comparable, more conventional structure to build.

Because of the research activities conducted therein, ORD-RTP provides a "worst case" example in building design. Provision must be made for the movement of heavy equipment and for the control of potential infectious agents related to animal research, of toxic gases, and of hazardous particles. The varied research projects conducted at RTP require special



Artist's concept of energy efficient building for research facility.

facilities such as high bay areas, explosion hazard laboratories, and animal care facilities in addition to general laboratories and office and administrative areas.

For this facility, many alternate technologies to reduce pollution and conserve energy — including solar collectors to provide space heating and cooling, fuel cells to produce electricity, and various energy recovery and storage systems — were found to be available. Efficient building design, in which effective insulation and other structural techniques are used also were found to provide means of saving energy and, thereby, reducing pollution.

The prototype building was designed with a minimum of exposed surface area to prevent unnecessary heat loss and gain. Forty percent of the structure is located underground where the natural insulating qualities of the earth reduce heating and cooling requirements. Solar-shared windows in the building allow the early morning sun to warm the interior and prevent overheating in the afternoon.

Solar collectors form the truncated south wall and absorb the sun's energy to provide most of the building's heat. Efficient, refrigerant-type heat systems allow economic energy utilization. Storage media, such as water, rocks, metallic sodium, or eutectic salts, prevent waste by retaining surplus energy until needed. Fuel cells, used to produce electricity, provide a non-polluting alternative to electric power generating plants.

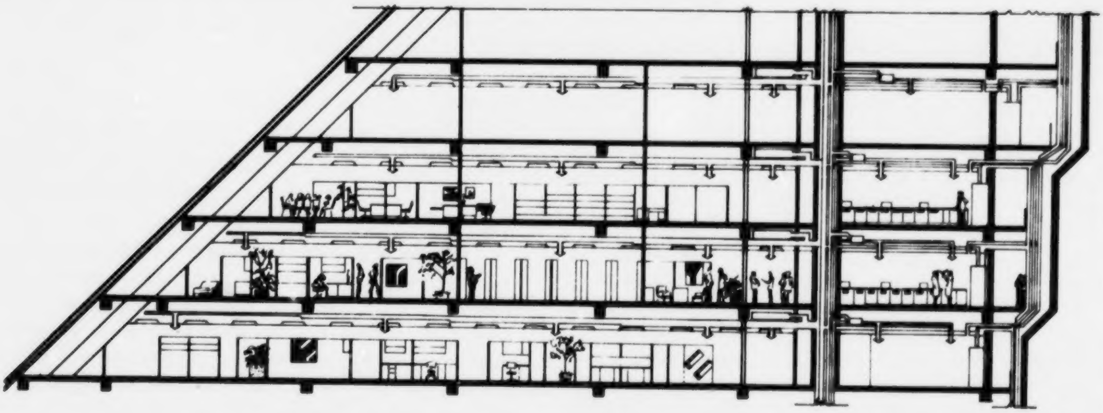
The compact building, which contains office, general laboratory, and special laboratory areas, consists of nine upper levels, a plaza, and two underground levels. Office areas are located under the solar collector wall, and modular laboratories form the north and west walls. The two lower levels project beyond the main building and house special services laboratories, high bay areas, explosion hazard laboratories, shops, and mechanical equipment storage areas. The lobby and administrative offices make up the plaza level.

Effective design provides for the efficient distribution of services within the structure. A mechanical service corridor parallels the north and west walls providing access to equipment as well as extra insulation for the laboratory area. Horizontal ducting carries the air to the offices and recirculates it through the laboratories for maximum heating and cooling efficiency. Fresh air supplied directly to laboratory exhaust hoods further reduces the demand on the ventilation system. Systems, located in the ducting, recover heat from the air before it is expelled through the exhaust shaft. These heat recovery systems, such as heat wheels and heat pipes, transfer heat from the warm exhaust air to the cooler intake air. Other systems recover as much as 80 percent of the heat dissipated by lighting fixtures. This heat, redistributed throughout the building, reduces demand on primary heating systems. During warm periods, lighting is a prime source of heat gain, and these recovery systems reduce the building cooling load by as much as 40 percent.

The adoption of energy-effective building design, the incorporation of efficient, non-polluting energy supply alternatives, and the utilization of energy recovery and storage systems are available methods of reducing energy demand and consumption. This prototype facility is an example of the energy savings and environmental benefits that can be achieved by proper design. The energy supply systems proposed for the structure operate at high efficiencies and reduce the need for fossil fuel combustion with its attendant high pollutant emission rates. Energy conservation through the use of high efficiency energy supply systems, alternate energy supplies such as solar energy, waste energy recovery systems, and energy storage will result in energy savings of at least 40 percent. Air pollution from energy supply is reduced to essentially zero.

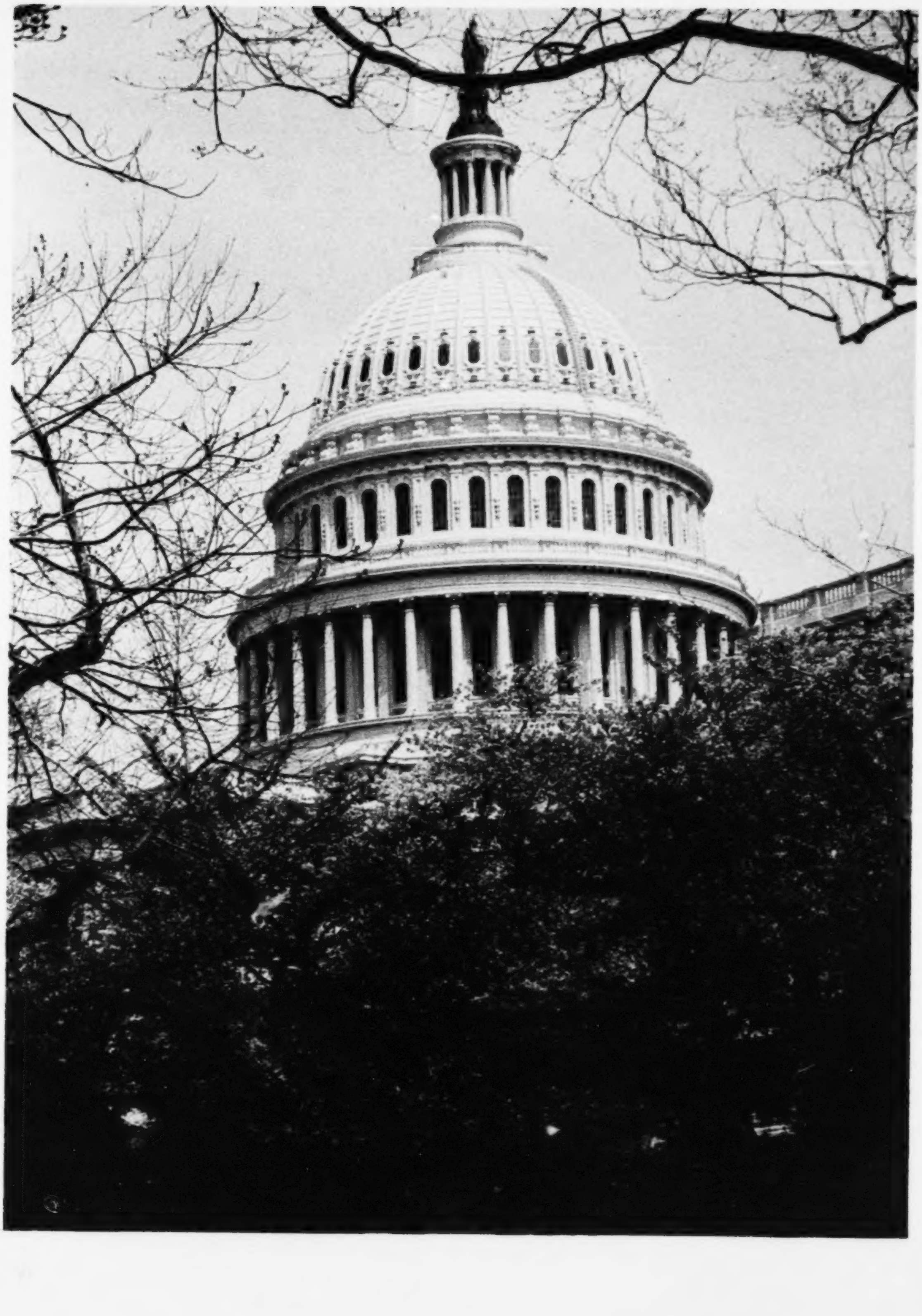
Economic savings are also a part of this design. The initial cost is equal to or less than that of a conventional structure, and the 40 percent savings in energy expenditures allows the initial construction costs to be recovered within the life of the structure.

A structure encompassing the technologies utilized in the prototype facility described by the study is proposed for EPA in Research Triangle Park. Construction of this facility would result in the achievement of significant savings in energy and reduction in pollution because of the building design and the integration of fossil-fuel-free energy technologies. With widespread use, such structures will provide a solution to many of our current pollution and energy problems.



Air is carried to the office areas and recirculated through the laboratories for maximum heating and cooling efficiency

LEGISLATIVE MANDATES



LEGISLATIVE MANDATES

ACTIVITIES OF ORD-RTP ARE EITHER in response to explicit mandates given in legislative acts or derived from language that requires the initiation of certain programs to carry out the intent of those mandates.

Brief narratives summarizing the activities of the appropriate ORD-RTP Laboratories in response to pertinent Sections of the Clean Air Act, the Public Health Service Act, the Federal Food, Drug, and Cosmetic Act, and the Federal Insecticide, Fungicide, and Rodenticide Act are presented below. Fiscal resources allocated to these seven Laboratories to carry out specific portions of the relevant Congressional Acts are summarized in Tables 4, 5, and 6.

Clean Air Act

Activities of ORD-RTP units are responsive to at least 13 Sections of the Clean Air Act: 103, 104, 108 through 113, 202, 211, 303, 312, and 313. The following portion of this section of this Report outlines each of the Sections and relates them to the activities of ORD-RTP laboratories.

SECTION 103: "RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES"

The essential feature of Section 103 is the requirement for EPA to establish a national research and development program for the prevention and control of air pollution. In addition to the conduct of in-house research studies, surveys, etc., the requirements include provision of assistance to other public and private agencies and institutions to conduct experiments, studies, demonstrations, and training activities, as well as technical services relating to the causes, effects, extent, and control of air pollution. To help meet these requirements, the Act authorizes EPA to establish technical advisory committees; to cooperate with and utilize the resources of other Federal, public, and private facilities; to make research grants and contracts; and to develop practical processes and methods for air pollution control. EPA is to emphasize short- and long-term effects of air pollutants on health and welfare by epidemiological, clinical, and laboratory studies.

Table 4 indicates that the largest category of activities at ORD-RTP is that which involves carrying out the mandates imposed by this Section of the Clean Air Act. All but one of the Laboratories are involved to some degree; over 90 percent of the resources of the Human Studies Laboratory (HSL) and the Meteorology Laboratory (ML) are so committed.

Research activities conducted at ORD-RTP are based on explicit environmental mandates of the Congress of the United States.

Table 4. SUMMARY OF RESOURCES EXPENDED BY ORD-RTP TO MEET LEGISLATIVE MANDATES OF CLEAN AIR ACT FOR FISCAL YEAR 1975
($$10^3$)

Section of Act	Laboratory[a]								
	OD	SSS	HSL	EBL	CPL	QAEML	ML	CSL	Total
103		510	11,231	2,160	956	1,115	3,268	3,329	22,569
104								2,929	2,929
108		367			1,808	107		1,598	3,880
109					901				901
110					1,922	1,485	330	1,598	5,335
111					1,959	525		3,035	5,519
112					516	415		799	1,730
113						173			173
202					758				758
211		1,064			1,520	310			2,894
303							33		33
312								27	27
313		10			333	180	50		573
Support	3,462								3,462
Total	3,462	1,951	11,231	2,160	10,673	4,310	3,681	13,315	50,783

[a] Office of the Director (OD), Special Studies Staff (SSS), Human Studies Laboratory (HSL), Experimental Biology Laboratory (EBL), Chemistry and Physics Laboratory (CPL), Quality Assurance and Environmental Monitoring Laboratory (QAEML), Meteorology Laboratory (ML), Control Systems Laboratory (CSL).

Table 5. SUMMARY OF RESOURCES EXPENDED BY ORD-RTP TO MEET LEGISLATIVE MANDATES OF PHSA, FIFRA, AND FWPCA[a]
($$10^3$)

Act	Office of the Director	Human Studies Laboratory	Experimental Biology Laboratory	Pesticides and Toxic Substances Effects Laboratory	Total
PHSA (Section 241)	121	389	1,450		1,960
FIFRA (as amended)	402		85		487
FWPCA (Section 104)	40	547		5,298	5,885
Total	563	936	1,535	5,298	8,332

[a] Public Health Service Act (PHSA); Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); Federal Water Pollution Control Act (FWPCA).

Table 6. SUMMARY OF ORD-RTP SPECIAL ENERGY APPROPRIATIONS FOR FISCAL YEAR 1975
($$10^3$)

	Human Studies Laboratory	Experimental Biology Laboratory	Chemistry and Physics Laboratory	Control Systems Laboratory	Total
Energy Appropriation	3,300	1,940	2,065	46,500	53,805

The Special Studies Staff (SSS) is concerned with the preparation, assessment, and dissemination of scientific and technical documents and publications related to air pollution research and control activities impinging upon the total research and development program, as well as on specific aspects commensurate with several provisions of this Section of the Act.

The effort of the Chemistry and Physics Laboratory (CPL) in this area deals primarily with studies relating to analytical methodology and atmospheric chemistry research.

The Control Systems Laboratory (CSL) conducts research to characterize emissions of pollutants, evaluate control technology, predict future needs, and develop and demonstrate the most promising and cost-effective control methods for stationary sources.

The Experimental Biology Laboratory (EBL) investigates the effects of gaseous and particulate pollutants on biological species, i.e., whole animal, organ, cellular, and sub-cellular components. Particular emphasis is given to effects on pulmonary defense mechanisms and pulmonary carcinogenesis and on the influence of interactions between coexisting pollutants and various physical factors upon these responses.

The development and conduct of studies designed to define relationships between environmental pollutants (singly or in combination) and specific undesirable health effects is the prime objective of HSL activities. Emphasis is given to the development of bases for ambient air and emission standards compatible with desirable aspirations for human health and welfare, and an evaluation of the health benefits that could be achieved. The assessment of adverse health effects and the economic costs that might result from any future revision of air quality standards is also a part of the HSL program.

The activities of ML focus upon research relating to the transport and dispersion of air pollutants, their effects on weather, visibility, and climate; and the relationship between weather factors and pollution. Dispersion model development and climatic analysis investigations improve understanding of the physical processes involved in (1) the relationships between source strength and receptor dosage, (2) the ultimate disposition (fate) of pollutants in the atmosphere, and (3) the delineation of a national climatology of the potential for adverse accumulations of air pollutants.

QAEML engages in the evaluation, testing, and standardization of methodologies for surveying the extent of air pollution as well as in the development of quality control procedures to ensure comparability of data wherever collected in the United States and for whatever purpose.

SECTION 104: "RESEARCH RELATING TO FUELS AND VEHICLES"

Section 104 charges EPA with the responsibility for conducting and supporting research into the development, laboratory and pilot testing, and demonstration of improved methods for the prevention and control of air pollution from combustion of fuels.

Activities by CSL under this mandate include the development of techniques for the reduction of nitrogen oxide emissions from combustion processes and the demonstration of commercially feasible means for the reduction of significant pollutants from coke oven emissions. Possibilities for effective, low-cost processes for cleaning coal are of current concern.

SECTION 108: "AIR QUALITY CRITERIA AND CONTROL TECHNIQUES"

EPA is required by Section 108 to ascertain those pollutants judged to have an adverse effect on public health and welfare and maintain an up-to-date list that it publishes from time to time. Air quality criteria for these pollutants must then be issued presenting the latest scientific knowledge on the kind and extent of identifiable effects that may be expected from varying concentrations of the pollutants in ambient air. Along with these criteria, information on air pollution control techniques or methods must be issued, including data on alternate fuels and processes that will result in elimination or significant reduction of the pollutant emissions.

Preparation of the criteria and scientific summary documents that serve as the legally defensible basis for the development of control strategies and the promulgation of ambient air quality standards is the responsibility of the Special Studies Staff.

A major program in CPL is the development of analytical methods and instruments to be used in health and welfare studies to aid in the evaluation or revision of air quality criteria. Also, considerable effort is going into the development of measurement technology for pollutants that may be considered candidates for air quality criteria, e.g., fine particles.

In support of this Section, CSL is evaluating new and existing stationary source control technology procedures on a continuing basis.

QAEML maintains the capability to evaluate methodologies and undertake surveys to obtain scientific information needed by the developers of the criteria documents.

SECTION 109: "NATIONAL AMBIENT AIR QUALITY STANDARDS"

For each pollutant for which an air quality criteria document has been issued, Section 109 of the Act requires that national primary and secondary ambient air quality standards be set. Primary standards concern the minimum level of air quality necessary to prevent adverse health effects; secondary standards are aimed at the prevention of adverse effects on "welfare"; e.g., plants, animals, materials, and climate.

Considerable effort in support of the standards is being made in CPL, particularly to further define the atmospheric relationships involving hydrocarbons and oxidants. Development of continuous measurement instrumentation for nitrogen dioxide (one of the pollutants for which standards have been set) and the evaluation of the reference method for measurement have been accomplished.

SECTION 110: "IMPLEMENTATION PLANS"

In accordance with a prescribed time schedule, Section 110 requires each state to prepare and submit to EPA a plan that provides for the implementation, maintenance, and enforcement of the primary and secondary ambient air standards promulgated in accordance with Section 109. In turn, EPA must make a thorough examination and evaluation of the plan's adequacy in technical concept and allocated resources. If a state fails to submit such a plan within the prescribed time, or if the plan is judged to be not in accordance with the requirements of this Section, then EPA must prescribe (or revise) a plan that meets the requirements. Section 110 also includes the steps and procedures for notices, hearings, or court actions that must or may be utilized in arriving at the objectives sought.

CPL is involved here to support development of chemical and physical air pollution models for reactive pollutants for use in implementation plans, including site criteria for large area sources.

CSL's role is primarily in providing expert testimony relating to the availability of air pollution control technology that could be incorporated in the implementation plans as they relate to the abatement of pollutants from specific sources.

ML provides direct assistance in the evaluation of the meteorological (i.e., transport and dispersion) portions of implementation plans.

QAEML activities support this Section by the evaluation and standardization of methods of measurement for the pollutants for which standards have been set, and by the development and dissemination of quality control procedures for the standardized methods.

SECTION 111: "STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES"

The emission of pollutants from new stationary sources must be regulated under Section 111 of the Act. Categories of such sources are to be established, and uniform national standards that would require application of the best available control technology, considering the cost, for air pollution prevention must be set. EPA must also determine the procedure that the states are to follow in setting emission standards for existing stationary sources.

Extensive support is provided by CPL in verifying and improving the reference methods of emission measurements and in developing performance criteria for the determination of compliance with the new source performance standards.

CSL evaluates the state-of-the-art air pollution control technology for various stationary sources and, based on projected future control needs, develops new control technology.

QAEML provides support here in a manner analogous to that for Section 110, again by the evaluation and standardization of measurement methods and by the development and dissemination of quality control procedures for the standardized methods.

SECTION 112: "NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS"

Section 112 gives EPA the authority to set national emission standards for hazardous air pollutants, defined as materials discharged into the atmosphere that have a proven relationship with increased mortality rates, or with incapacitating or serious illness.

CPL is responsible for developing the analytical methodology for the national emission standards for hazardous materials. Improved sampling and analysis methods are under development for a number of substances including asbestos, mercury, and polycyclic organic matter.

The identification of all air pollutants from stationary sources is included in the programs of CSL. As the need for control is indicated, the best technological possibilities and the most cost-effective approaches are sought through related research programs.

Again, QAEML support is in terms of measurement methods standardization and quality control procedures. Technical assistance to other EPA units is also rendered to obtain data to assist in the determination of what constitutes a hazardous pollutant.

SECTION 113: "FEDERAL ENFORCEMENT"

The legal actions that EPA must take in the event that violations of an implementation plan are encountered are contained in Section 113. This Section also cites penalties to be assessed for non-compliance with the Administrator's orders.

QAEML maintains a limited rapid-response capability to assist in the collection of data for purposes of Federal enforcement

SECTION 202: "ESTABLISHMENT OF STANDARDS"

In accordance with the provisions of Section 202, EPA must establish standards of emission for any pollutant from new motor vehicles that is likely to endanger public health or welfare. Section 202 also delineates a time schedule for achieving a large (90 percent) reduction in carbon monoxide and hydrocarbons; additionally, the Section outlines a certification plan for ensuring compliance with the standards by the manufacturers.

CPL provides support in development of emission protocols for fuel additive effects and in characterization of emissions from vehicles either equipped with control devices or utilizing alternate power systems.

SECTION 211:"REGULATION OF FUELS"

Section 211 stipulates that no fuel or fuel additive may be offered for sale until the manufacturer has notified EPA of the product's chemical composition and EPA registers the product. If the fuel or additive endangers public health or interferes with the performance of anti-pollution devices, its use may be restricted or banned. EPA may require tests by the manufacturer to determine such effects.

The fuel and fuel additive registration program is one of the areas of responsibility of the Special Studies Staff. This program involves information retrieval activities in addition to the conduct of research programs to develop protocols that will allow the valid assessment of the effect of fuel components on emission products.

CPL develops emission protocols for fuel additive effects and characterizes the emissions from vehicles equipped with control devices and advanced alternate power systems.

The support of this Section by QAEML is in the development and evaluation of methods of analysis and in the collection and analysis of fuel samples.

SECTION 303: "EMERGENCY POWERS"

Section 303 provides EPA with the authority to act immediately to restrain the emission of pollutants presenting an imminent and substantial danger to the health of persons when appropriate state or local authorities have not acted to abate such sources.

ML provides direct meteorological support for the assessment of weather factors and consequences in actual or potential emergency or accidental air pollution episodes.

SECTION 312: COMPREHENSIVE ECONOMIC COST STUDIES"

Included in Section 312 is the requirement for EPA to make a comprehensive study of the economic impact of air quality standards as well as an analysis of the national requirements for, and the cost of, controlling emissions to attain those standards.

In this connection, CSL undertakes research and demonstration projects leading to the development of comprehensive data relating to the cost of various air pollution control techniques.

SECTION 313: "ADDITIONAL REPORTS TO CONGRESS"

The Administrator is required to submit annual reports to Congress giving the progress made in implementing the purpose and intent of the Clean Air Act (and amendments). Included must be statements of the (1) status of enforcement actions, (2) progress on control techniques, and (3) standards set or under consideration.

The Special Studies Staff has a major responsibility in the preparation of such reports to Congress and in the identification of problems and additional research efforts that should be brought to the attention of that body.

CPL provides input to the progress reports to Congress on air quality and emission instrumentation and on emission standards for moving vehicles.

ML contributes to these reports by interpreting the effects of weather and climatic factors on existing or proposed air pollution control strategies to ensure that the effects of abatement actions can be isolated from natural variations.

Air quality and emissions data, as well as measurement methods developments, by QAEML are often included in the reports to Congress.

Public Health Service Act

SECTION 241: "RESEARCH AND INVESTIGATIONS"

Section 241 of the Public Health Service Act authorizes research, investigations, experiments, demonstrations, and studies relating to the causes, diagnosis, treatment, control, and prevention of physical and mental diseases and impairments of man. Under this broad charge, EPA has the responsibility to provide Federal guidance on both ionizing and non-ionizing radiation problems affecting health. This responsibility includes the authority to establish environmental standards for safe levels of radioactive materials.

The Experimental Biology Laboratory conducts an extensive program on the known and potential health effects of electromagnetic non-ionizing radiation and ionizing radiation; studies involving the latter are centered about the potential health effects of tritium and krypton-85, both of which are major potential effluents from nuclear fuel reprocessing plants.

Epidemiologic studies on the effects of exposures from radioactive materials in Japan are under the jurisdiction of HSL.

FDCA and FIFRA

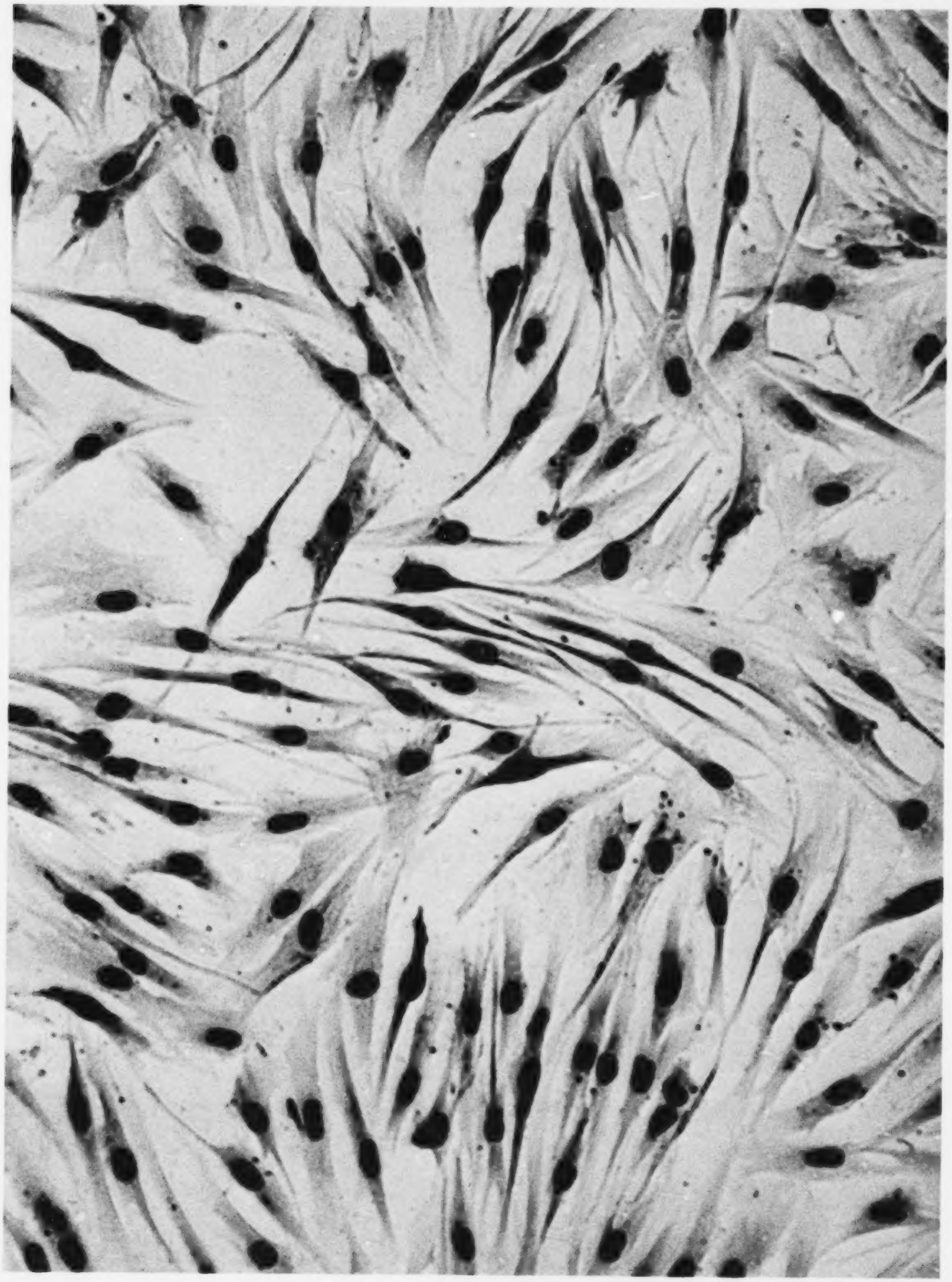
Provisions of the Federal Food, Drug, and Cosmetic Act and the Federal Insecticide, Fungicide, and Rodenticide Act, taken together, seek to protect the safety of the nation's food supply by preventing contamination that might arise through the use of chemical controls to protect crops and livestock from pests and diseases. These provisions require the registration (with EPA) of all such "poisons" as well as the filing of all test results and claims made for them. Also required by these Acts is the establishment of tolerances for pesticides in or on both human and animal food; this responsibility has been delegated to EPA. This provision means that "registration for use" of a pesticide that would leave a residue on a food or feed crop is granted only when a tolerance established by EPA has been satisfied. Interstate shipment of non-registered products is prohibited.

The entire resources of the Pesticides and Toxic Substances Effects Laboratory (PTSEL) are devoted to support of the responsibilities delegated to EPA to carry out provisions of these Acts. The resources are devoted primarily to research activities to support registration decisions and to determine and analyze levels of pesticide residues in or on agricultural products. In particular, data from acute, subacute, and chronic studies of laboratory animals and exposed human subjects are used to augment basic knowledge for continued registration of toxic substances for use in the United States.

RESEARCH ACTIVITIES

In this Section, the seven Laboratories that comprised the National Environmental Research Center at Research Triangle Park are presented under the new four-laboratory organizational structure of the Office of Research and Development-Research Triangle Park described in the Preface.

Health
Effects
Research
Laboratory



Special Studies Staff

OVERVIEW OF SSS MISSION

The Special Studies Staff is engaged in activities in three major technical areas: (1) preparation of air quality criteria documents and scientific and technical assessment reports involving pollutant characterization, (2) fuel and fuel additive registration and vehicular emission research, and (3) participation in or coordination of ORD-RTP international activities. In addition, the Staff carries out various *ad hoc*, short-term projects.

ORGANIZATION

The Special Studies Staff, functioning under the general guidance of a Director, concentrates on two subject areas—Pollutant Characterization and Fuels and Fuel Additives Registration.

To meet its responsibilities in pollutant characterization, fuels and fuel additives registration, and international activities, the Special Studies Staff emphasizes both extramural tasks with supporting in-house activities to obtain basic and background information, and direction and coordination of in-house ORD-RTP task force activities concerning preparation of multidisciplinary and multimedia environmental pollutant scientific and technical assessment reports.

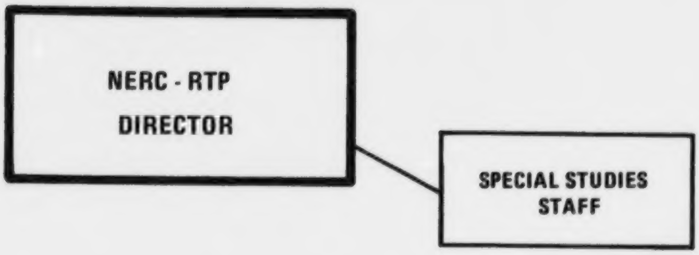
Pollutant Characterization

Personnel involved in the pollutant characterization program produce technical documentation to be used in decision-making regarding pollution control. This group assists international organizations in preparing similar technical documentation. Involvement begins with a search for basic information and extends through publication of the document. The Staff Director coordinates ORD-RTP's international activities.

Fuels and Fuel Additives Registration

The Fuels and Fuel Additives Registration group is involved in receiving and storing information from manufacturers as required by law and registering their products. Personnel also assist in the development of related regulations and guide research carried out external to the immediate group.

Giemsa-stained, human skin fibroblasts are shown (magnified) after 1-day exposure in control culture.



MAJOR PROGRAM AREAS

Pollutant Characterization

The pollutant characterization activities of the Special Studies Staff provide documentation critically reviewing, evaluating, comparing, interpreting, and summarizing pertinent literature and reports. This documentation leads to the (1) revision of existing criteria documents or the preparation of additional scientific and technical assessment reports concerning air quality effects of currently non-regulated environmental pollutants, (2) identification of the need for additional research required to produce adequate criteria for issuing or revising standards, and (3) preparation of briefing reports that address new areas of environmental concern that are not already part of an integrated program.

Air quality criteria, as defined by the Clean Air Act, are compilations of the latest available scientific information on the sources, prevalence, and manifestations of recognized air pollutants. Most importantly, these criteria describe the effects that have been associated with, or may be expected from, an air pollutant level in excess of a specific concentration for a specific time period. Such effects generally involve visibility reduction, damage to materials, economic costs, vegetation damage, nuisance aspects, and adverse effects on the health and well-being of humans and animals. Air Quality Criteria serve as the basis for national ambient air quality standards.

The scientific and technical assessment reports serve two very important purposes. They summarize the scientific knowledge base for administrative decisions regarding the need and strategy for control, and they provide important input for research and development program plans. In view of their widespread distribution, these documents also serve as an important communications link with other EPA offices, other agencies, and special-interest groups. In order to serve these purposes, they must be functional documents, clearly and concisely written.

Assessment reports are prepared under the supervision of the Special Studies Staff by task forces made up of staff members from the Laboratories at RTP and from the other ORD locations. The reports are based on a standard outline to ensure inclusion of available information on the following items:

- Chemical and physical properties.
- Measurement techniques applied to various environmental compartments (e.g., air, water, and soil), sources, and (when pertinent) biological samples.
- Origin and abundance.
- Concentrations in air, water, soil, plants, animals and humans, and microorganisms.
- Transformations and transport.
- Environmental exposure.
- Mechanisms of exposure.
- Physiological response.
- Undersirable effects on humans, animals, vegetation, materials, weather, visibility, climate, and land and water resources.
- Control technology and remedial actions.
- Current research and development activities.

These reports are generally based on review material provided by panels of experts assembled by the National Academy of Sciences (NAS) under contract with the Special Studies Staff, although other organizations have provided similar resources. Supplementary information is used as available and required. When no basic review document is available, the basic literature is searched.

Basic review documents are being prepared by NAS on vapor-phase organic matter, chlorine, selenium, copper, zinc, arsenic, and the platinum-group heavy metals. In keeping with timely review of criteria documents, NAS is preparing reviews on carbon monoxide, photochemical oxidants, nitrogen oxides, and fine particulate matter. NAS recently submitted to the Special Studies Staff reports on nickel, chromium, and vanadium. Task forces are currently preparing reports on vanadium, chromium, nickel, nitrates, vinyl chloride, and lead from stationary sources.

Reports on particulate, polycyclic organic matter, sulfates and sulfuric acid aerosols, polychlorinated biphenyls, cadmium, and manganese are now being finalized prior to publication.

The Special Studies Staff completed a review and revision of the vegetation effects chapter of *Air Quality Criteria for Sulfur Oxides* in 1973, requiring EPA review of the secondary standards for sulfur oxides that led to the standards' revision. The Special Studies Staff has also prepared and presented briefings for EPA's Office of Research and Development (ORD) on fine particulate matter and nitrates.

Scientific and technical assessment reports are to be prepared for selenium, chlorine/hydrochloric acid, arsenic, vapor-phase organic matter, copper, zinc, and platinum-group heavy metals. A briefing document on particulates from mobile emissions is also to be prepared. The air quality criteria documents for nitrogen oxides, photochemical oxidants, hydrocarbons, sulfur oxides, particulates, and carbon monoxide are to be updated and/or revised.

Fuels and Fuel Additives

Registration

The Fuels and Fuel Additives Registration program, reorganized in Fiscal Year 1974, involves registration, emissions characterization, toxicological testing, human studies, fuel surveillance and analysis, health and welfare effects, and the development of related effects protocols. These subject areas provide a complex, interrelated, multidisciplinary technical program, the objective of which is to ensure the continued protection of the public health and welfare as it relates to the mobile source emissions control program, and the effects that fuels, fuel additives, advanced control devices, and alternate power systems have thereon. The development and review of this integrated program, which is the responsibility of the Special Studies Staff, includes the review, evaluation, and reporting of data collected and proposals for necessary action.

Registration—Additives used in gasoline introduced into interstate commerce must be registered with EPA. At the present time, some 373 such additives are registered in a number of chemical classifications.

Emission Characterization—Characterization of both regulated and non-regulated exhaust pollutants and the effect of fuel components and fuel additives thereon are essential to provide the preliminary information required to assess potential adverse effects of such fuel components or additives on emissions and emission control device performance. In addition, detailed characterization of exhaust products resulting from combustion of fuels with and without additives and of products emanating from catalytic control devices and alternate power systems is essential in order to provide the data necessary to conduct meaningful health effects studies.

A result of this program has been a reassessment of the public health benefit related to the use of oxidation catalysts on mobile sources and the attendant increase in levels of potentially hazardous non-regulated emissions.

Emissions Effects Protocols—EPA may require that tests be conducted by any fuel or fuel additive manufacturer to ascertain the effects of such fuel or fuel additive on both emissions and control device performance. Such tests are to be based on protocols specified by the Administrator and are largely extensions of the research programs outlined previously under *Emission Characterization.*

Surveillance—Collection and analysis of commercial fuels, crankcase oils, and diesel fuels are essential to ensure both the valadity of the registration information upon which the research program is based and the dependable performance of consumer-operated advanced control systems that already have been shown to be sensitive to particular fuel and oil components and additives. This activity is just getting under way.

Health Effects Assessment—The Agency is developing the health intelligence necessary to ensure that public health is protected by the mobile source emissions control program. Available serviceable toxicologic models and human exposure study techniques can provide a reasonable data base for decision-making. Although a hierarchical screening system has not been developed, there is no doubt that such a system would be most valuable in obtaining answers to key health questions more rapidly. The program gives immediate priority to toxicologic assessment (using simple and relatively rapid techniques) of new compounds believed likely to occur in auto emissions.

International Activities

The Special Studies Staff fills a dual role in international activities, not only serving as the ORD-RTP focal point for international activities, but also providing direct assistance in developing criteria reports and other documents. The Staff also provides a number of miscellaneous services including arranging briefings for international scientists, responding to inquiries and receiving and channeling research proposals to appropriate Laboratories.

World Health Organization—Since 1971, the ORD-RTP has served as the WHO International Reference Center for Air Pollution Control. The Special Studies Staff makes a sizeable contribution to WHO under the terms of the Reference Center Agreement, including coordination of the yearly contractual agreement, providing temporary advisers on a fairly frequent basis, assisting Laboratories in fulfilling the tasks they have agreed to perform under

The Special Studies Staff documents the latest available scientific information on the sources, prevalence, and manifestations of recognized air pollutants.

the contract, and finally, contributing directly to criteria and assessment documents – or, in some cases, contributing entire documents. During 1974 the staff contributed documents entitled *Environmental Health Criteria for Manganese and its Compounds* and *Environmental Health Criteria for Polychlorinated Bi- and Terphenyls* for the WHO Environmental Health Criteria Programme.

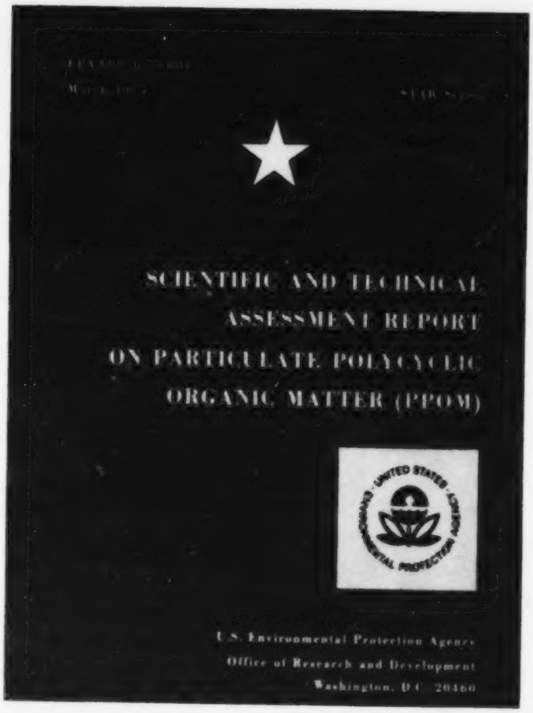
Organization for Economic Cooperation and Development—Contributions to various efforts of the OECD are made as requested. Most recently, the Special Studies Staff contributed information to a three-nation comparative study on the use of criteria and effects data as a basis for decision-making in pollutant control. The Staff prepared a paper entitled "Case History on the Use of Criteria and Effects Data as the Basis for Decisions on the Control of Sulfur Dioxide in the United States" and participated in the writing of a collaborative study report.

Pan-American Medical Association—The Director of the Special Studies Staff has accepted appointment as Secretary of the new PAMA section on Environmental Health Sciences. Duties will include recommending appropriate members and vice presidents, and participating in planning of PAMA Congresses.

U. S.-Federal Republic of Germany—Members of the Special Studies Staff have been involved in the progress of the U. S.-Federal Republic of Germany (FRG) Agreement for a number of years. During 1974, the Staff met with a representative of the FRG Ministry of the Interior and, in response to this meeting, provided the FRG with reports on particulate polycyclic organic matter, polychlorinated biphenyls, cadmium, manganese, and vanadium.

Special Foreign Currency Program—Direction of Public Law 480 projects is distributed throughout ORD-RTP according to subject matter of the agreement. (Public Law 480 provides for research endeavors in foreign countries using currencies from the sale of surplus U.S. agricultural commodities). One of the projects being carried out in Yugoslavia is appropriate to the assessment goals of the Special Studies Staff, which provides the project's direction. This study considers the effects of manganese on a selected population, including factory workers.

Internation Contracts—The Karolinska Institute is under contract to provide reviews on the toxicity of several metals, including cadmium, mercury, antimony, cobalt, and molybdenum.



SCIENTIFIC AND TECHNICAL
ASSESSMENT REPORT
ON PARTICULATE POLYCYCLIC
ORGANIC MATTER (PPOM)

U.S. Environmental Protection Agency
Office of Research and Development
Washington, D.C. 20460

Scientific and Technical Assessment Reports describe environmental pollutants.

LEGISLATIVE MANDATES

The legislative mandates upon which the Special Studies Staff's programs are based and the various sections of the Clean Air Act requiring Staff support are shown below with a brief description of the types of activities engaged in to support the mandate and the Act.

"RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES

"Sec. 103. (a) The Administrator shall establish a national research and development program for the prevention and control of air pollution . . .

"(b) In carrying out the provisions of the preceding subsection the Administrator is authorized to—

"(1) collect and make available . . . the results of and other information, including appropriate recommendations by him in connection therewith, pertaining to such research and other activities . . .

"(7) collect and disseminate . . . basic data on chemical, physical, and biological effects of varying air quality and other information pertaining to air pollution and the prevention thereof . . .

"(c) In carrying out the provisions of subsection (a) of this section the Administrator shall conduct research on, and survey the results of other scientific studies on, the harmful effects on the health or welfare of persons by the various known air pollutants . . .

"AIR QUALITY CRITERIA AND CONTROL TECHNIQUES

"Sec. 108. (a) . . . (2) The Administrator shall issue air quality criteria for an air pollutant . . . Air quality criteria for an air pollutant shall accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare which may be expected from the presence of such pollutant in the ambient air, in varying quantities . . .

"(b) (1) Simultaneously with the issuance of criteria under subsection (a), the Administrator shall . . . issue . . . information on air pollution control techniques . . . Such information shall include such data as are available on available technology and alternative methods of prevention and control of air pollution . . .

"(c) The Administrator shall from time to time review, and, as appropriate, modify, and reissue any criteria or information on control techniques issued pursuant to this section . . .

"ADDITIONAL REPORTS TO CONGRESS

"Sec. 313 . . . the Administrator shall report to the Congress on measures taken toward implementing the purpose and intent of this Act including, but not limited to . . . (2) the development of air quality criteria and recommended emission control requirements . . . (4) the status of State ambient air standards setting, including such plans for implementation and enforcement as have been developed . . ."

As indicated above, Sections 103, 108, and 313 of the 1970 Clean Air Act Amendments permit EPA's Administrator to require the preparation of scientifically sound assessment or criteria documents to serve as the legally defensible basis for both the development of control strategies and the promulgation of standards. The preparation of criteria documents and scientific and technical assessment reports by this Staff contributes to the requirement of these sections of the Act.

Characterization of pollutants consists of critically reviewing, evaluating, comparing, and interpreting pertinent literature to revise present, or prepare additional, air quality criteria documents and prepare scientific and technical assessment reports that serve as the scientific basis of control strategies and related standards. These documents are also required to identify the need of additional research for producing adequate criteria for issuing or revising standards.

"REGULATION OF FUELS

"Sec. 211. (a) The Administrator may by regulation designate any fuel or fuel additive and . . . no manufacturer or processor of any such fuel or additive may sell, offer for sale, or introduce into commerce such fuel or additive unless the Administrator has registered such fuel or additive in accordance with subsection (b) of this section.

> **"(b) (1) For the purpose of registration of fuels and fuel additives, the Administrator shall require—**
>
> **"(A) the manufacturer of any fuel to notify him as to the commercial identifying name and manufacturer of any additive contained in such fuels . . .**
>
> **"(B) to furnish . . . such other information as is reasonable and necessary to determine the emissions resulting from the use of the fuel or additive contained in such fuel, the effect of such fuel or additive on the emission control performance of any vehicle or vehicle engine, or the extent to which such emissions affect the public health or welfare . . .**
>
> **"(c) (1) The Administrator may, from time to time on the basis of information obtained under subsection (b) of this section . . . control or prohibit the manufacture, introduction into commerce, offering for sale, or sale of any fuel or fuel additive for use in a motor vehicle or motor vehicle engine . . ."**

Sections 211 (a) and (b) of the 1970 Clean Air Act Amendments permit the Administrator to require the registration of fuels and fuel additives as a prerequisite to sale. These sections also permit the Administrator to require, as a prerequisite to registration, that tests be conducted by the manufacturer to determine the effect of such fuels or fuel additives on emissions (regulated and non-regulated), the performance of emissions control devices, public health, and public welfare. Such tests are to be conducted on the basis of protocols established by the Administrator.

Section 211 (c) provides that any registered fuel or fuel additive may be restricted or prohibited based upon adverse effects observed from such tests or from other such information available to the Administrator.

The Special Studies Staff's fuels and fuel additives program consists of registration and information retrieval activities in addition to conducting research programs to develop protocols that will allow the valid assessment of the effect of fuel components and fuel additives on emission products (both regulated and non-regulated), performance of emission control devices, atmospheric loadings and transformations, and public health and welfare.

By contractural agreement with the World Health Organization (WHO), EPA was established as WHO's International Reference Center for Air Pollution Control (IRCAPC). The responsibility for responding to WHO requests was assigned to ORD-RTP by EPA's Assistant Administrator for Research and Development who is also the Director of WHO-IRCAPC.

The Special Studies Staff's international activities consist of providing direct technical assistance and liaison to international organizations in preparing international environmental pollutant criteria and guidelines as well as coordinating other ORD-RTP involvement with the WHO, the Organization for Economic Cooperation and Development (OECD), NATO's Committee on the Challenges of Modern Society, the Special Foreign Currency Program, the World Meteorological Organization (WMO), the Economic Commission for Europe, and the Commission of the European Communities.

Special Studies Staff resources are summarized in Table 7.

Table 7. SUMMARY OF RESOURCES FOR SPECIAL STUDIES STAFF FOR FISCAL YEAR 1975

Section of Clean Air Act supported	Funds, $\$10^3$
103	510
108	367
211	1,064
313	10
Total	1,951

Human Studies Laboratory

OVERVIEW OF HSL MISSION

The mission of the Human Studies Laboratory is to define the influence of environmental stress on human health so that appropriate steps can be taken to meet the requirements of the Clean Air Act. The Laboratory must also recognize and define new problem areas in environmental health as new technologies emerge. In addition, it must provide technical assistance to the Agency during pollution emergencies and during public hearings on control activities.

ORGANIZATION

The HSL is divided into the Office of the Director and five Branches. The Office of the Director coordinates all Laboratory activities, develops long- and short-term research goals, and periodically reviews the progress of Laboratory programs.

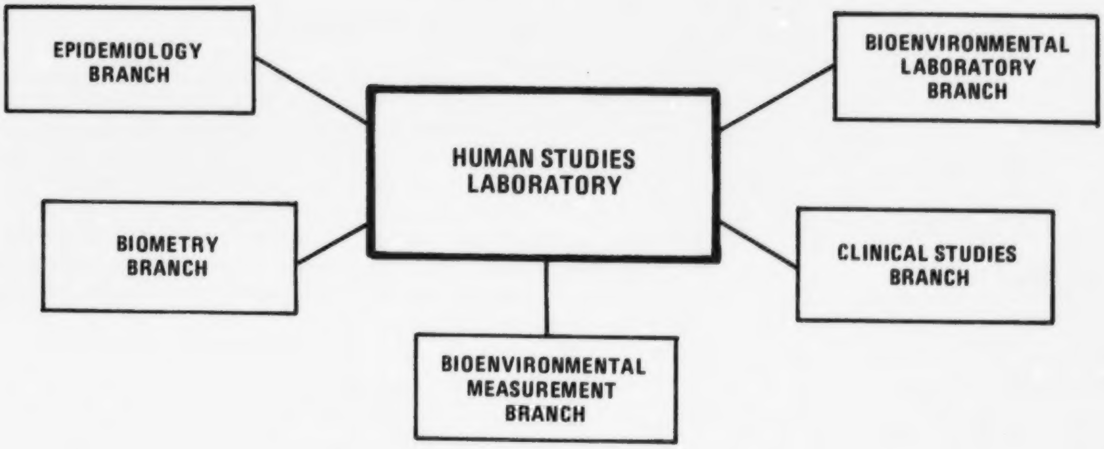
The Epidemiology Branch studies the effects of pollution on human health and searches for predisposing factors that worsen or contribute to the development of various diseases. In addition, the Branch assesses the impact upon health and welfare of improvements in environmental quality resulting from efforts to control pollution.

The Biometry Branch is responsible for the design and analysis of research studies and provides statistical design and analysis, computer programming, and data processing services. The Branch conducts research in statistical and computer-oriented areas related to the mission of the Laboratory.

The Bio-Environmental Measurement Branch conducts a comprehensive program of environmental measurements of pollutants in controlled laboratory environments and in ambient polluted environments. These measurements are related to the physiological and pathological responses of human subjects exposed to environmental pollutants in bio-medical laboratory studies and of selected segments of the populations in epidemiologic studies.

The Clinical Studies Branch conducts laboratory studies to detect and define effects of environmental pollutants on human health, to verify correlative epidemiological findings, and to develop or improve methodology for application to human health effects studies in laboratory and in community settings.

The Bio-Environmental Laboratory Branch (BELB) works in cooperation with the other Branches of HSL to describe human metabolic response to pollutant exposure. The BELB program includes performing chemical analyses of environmental and biological samples, as well as conducting research to



determine appropriate methodology for the analyses of trace environmental or biological specimens. The Branch is also developing methods for determining the level of human exposure to various pollutants. The objective is to demonstrate a dose/response relationship for exposure to a given pollutant species and a specific metabolic parameter prior to permanent or serious injury.

PHYSICAL FACILITIES

The Human Studies Laboratory has facilities at RTP and in Chapel Hill, North Carolina. Laboratories in both locations are equipped with the most modern analytical instruments, including gas/liquid chromatographs, an atomic absorption spectrometer with heated graphite atomizer, ultra-centrifuges, disc gel and slab electrophoresis devices, radioactive strip scanning devices, and liquid scintillation spectrometers.

Twenty-three Community Health and Ambient Monitoring Program (CHAMP) stations are being updated and equipped with the best technology available in sensors complemented by automatic electronic data acquisition with remote magnetic tape storage and "on-call" telemetric output and visual field data inspection.

The Clinical Studies Branch is located in the Clinical Environmental Research Laboratories building on the periphery of the University of North Carolina Medical Center complex in Chapel Hill. This special-purpose building was constructed specifically to assist in fulfilling EPA medical research objectives and to provide special-purpose laboratories and support areas. These special-purpose laboratories include:

- Controlled human exposure facilities in which varied exposures to air pollutant concentrations or noise levels can be produced.
- Cardiovascular research facilities for validating measurement techniques and for obtaining cardiovascular data from studies on animals and humans.
- Psychophysiology facilities in which human behavioral and psychophysiologic studies are conducted.
- Microbiology facilities in which effects of environmental stress and human immune mechanisms are studied.
- Pulmonary physiology facilities in which new techniques for human pulmonary function measurement are developed and validated.
- Clinical metabolism facilities in which routine and specialized human clinical chemistry analyses are performed.
- Pulmonary research facilities at the Frank Porter Graham Child Development Center in Chapel Hill, the exercise physiology laboratory, and the pathology laboratories in which specialized research is conducted.

In addition to the above facilities, HSL has an optical reader for directly processing health questionnaire data onto magnetic tape and computer terminals that provide direct access to EPA's Computer Center at RTP.

MAJOR PROGRAM AREAS

HSL research activities are in two major program areas: field epidemiological studies in ambient pollution exposure situations and clinical (laboratory) studies on human subjects under experimentally produced exposure conditions. The various studies are integrated or complementary in a manner designed to provide the broadest possible response to the needs of the Agency.

Epidemiologic Studies

The Community Health and Environmental Surveillance System (CHESS) is a nationwide research project designed to investigate relationships between air quality and human health. To accomplish this, standardized epidemiologic studies are currently conducted in 22 communities located in 5 metropolitan areas across the country. In each, community health information is collected from individuals and families residing within 2 miles (3.2 km) of an air monitoring station.

Among the major objectives of CHESS are the development of estimates of exposure-response relationships and injury thresholds for pollutants and the documentation of changes in health status coincident with temporal changes in environmental quality. The ability to accomplish these objectives depends upon valid quantification of health parameters as well as precise measurement of exposure.

In early 1974, the results of specific epidemiologic studies were published in a monograph entitled *Health Consequences of Sulfur Oxides: A Report from CHESS, 1970-1971.* In these studies, a consistent pattern of excess chronic bronchitis prevalence rates was observed among residents of the more polluted CHESS communities. In the Salt Lake (Utah) survey, both smokers and nonsmokers showed an excess in chronic respiratory disease among males, and chronic bronchitis rates and symptom scores (numerical indices of respiratory symptom severity) were higher among male and female smokers than among other groups. Moreover, male and female nonsmokers, exsmokers, and current smokers from more polluted areas had higher bronchitis rates and symptom scores than those from less polluted areas.

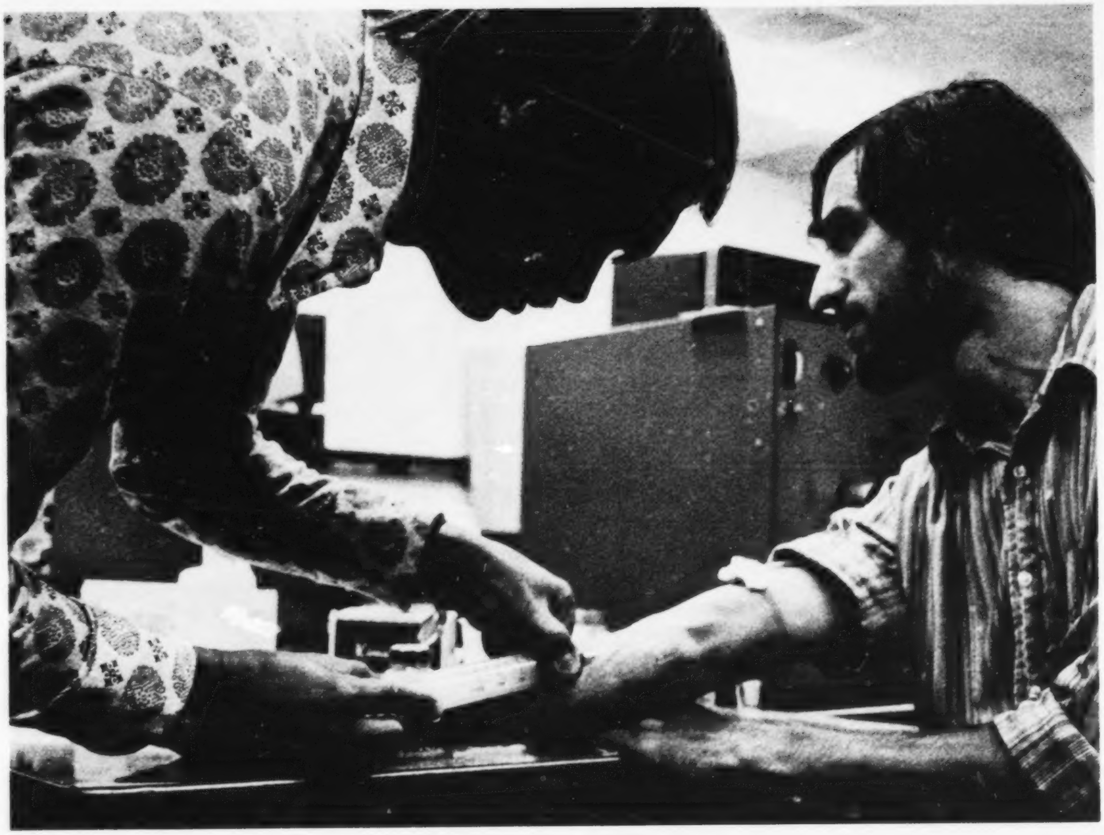
Among young, white military recruits in the Chicago, Illinois, area, the contribution of air pollution to chronic bronchitis rates was relatively much less than that of cigarette smoking. Even among these young inductees, however, respiratory symptoms were more prevalent among persons from more polluted communities.

In studies conducted in the Salt Lake Basin and Rocky Mountain CHESS areas, no statistically significant association was found between total lower respiratory disease and air pollution for children whose parents had been residents of their communities for less than 3 years. For single and repeated episodes of croup and repeated episodes of any lower respiratory disease, families of children who had lived 3 or more years in the high-exposure communities reported more illness across all ages of children from 0 to 13 years than did their counterparts in the less polluted communities.

Studies of total acute respiratory disease rates were also conducted among families in Chicago and New York. These CHESS findings showed that a consistent excess in acute respiratory disease was reported among family members living in more polluted neighborhoods, with the exception of fathers, who often have greater occupational exposures and greater daily changes in exposure because of their work locations. In each of three New York neighborhoods, cold temperatures were directly related to increased symptom rates in subjects with combined heart and lung disease. Among the pollutants considered, only elevated levels of suspended sulfates were consistently associated with symptom aggravation. Daily sulfur dioxide and total suspended particulate concentrations, for example, could not be associated with symptom aggravation in individuals with heart and lung disease, whose reaction to variations in daily pollutant concentrations is most sensitive.

Compilation of data for a second monograph in which the health consequences of exposure to suspended particulate are examined was completed in 1974; publication of the information is expected in late 1975. Based on these data, best judgment estimates of the lowest annual mean levels of air pollution that might cause adverse health effects are given in Table 8. In relating observed health effects to pollutant concentrations, three estimates are given: a worst case estimate, which attributes an adverse health effect to the lowest pollution exposure suggested by epidemiological studies; a least case estimate, which attributes an observed health effect to the highest pollution exposure suggested by the studies; and a best judgment estimate based on several studies.

Similar estimates relating short-term pollutant exposures to adverse effects on human health are given in Table 9. Worst case estimates of levels of pollution exposure associated with increased attacks in asthmatics reflect the lack of association observed between attack rates and measured exposure levels for total suspended particulate and respirable size particulate. The data given in Table 9 suggest only



Blood sample for chromosome analysis is drawn from volunteer exposed to ozone in laboratory test.

that concentrations of less magnitude appear to have no effect.

Studies designed to document the benefit of pollution control were continued in areas of higher pollution exposure across the country. These studies will attempt to measure the health impact of the shift from low- to high-sulfur fuels, and from gas or oil to coal, by power plants and industry.

Several new pilot studies were initiated during 1974. For example, admissions to the emergency room of a large hospital were investigated as a health indicator sensitive to varying levels of ozone. Another study investigated total or specific daily mortality rates as an indicator sensitive to different ozone concentrations.

Methods of determining the environmental sources of lead in children who exhibit unduly high levels of absorption of the metal were studied with the objective of determining the contribution of airborne lead fallout to total lead ingested by children. Still another study was designed to determine whether children who have a past history of apparent excessive lead exposure exhibit a greater frequency of altered neurophysiological behavior than a comparable group of children without this history.

Bio-environmental Measurements

Community Health Air Monitoring Program (CHAMP)—The relationship between human health and community air quality is being determined by comparing the state of health of population groups residing in communities exposed to definable air pollutants that are characteristic of certain sources or

Table 8. SUMMARY OF STUDIES RELATING LONG-TERM POLLUTANT EXPOSURES TO ADVERSE EFFECTS ON HUMAN HEALTH

Adverse effect	Type of estimate	Duration of exposure, years	Annual average levels[a] associated with adverse effects, $\mu g/m^3$				
			TSP	RSP	SS	SN	SO_2
Increased chronic respiratory disease	Worst case	1	63-84	34-45	13-17	2	51
	Least case	10	170	85	14-19	4	40
	Best judgment	6	100	52	14	3	95
Increased lower respiratory disease	Worst case	1	60	34	13	2-3	50
	Least case	3	>110	>60	15	2-4	>177
	Best judgment	2	90	50	14	3	95
Increased acute respiratory disease	Worst case	1	85	45	10	2	50
	Least case	5	102	55	12	3	210
	Best judgment	3	90	50	12	3	106
Decreased ventilatory function in children	Worst case	1	85	40	12	2	57
	Least case	5	>140	55	14	2	435
	Best judgment	5	120	50	13	3	200

[a] TSP = total suspended particulate, RSP = respirable size particulate, SS = suspended sulfate, SN = suspended nitrate, SO_2 = sulfur dioxide.

Table 9. SUMMARY OF STUDIES RELATING SHORT-TERM POLLUTANT EXPOSURES TO ADVERSE EFFECTS ON HUMAN HEALTH

Adverse effect	Type of estimate	24-hour mean levels[a] associated with effect, g/m				
		TSP	RSP	SS	SN	SO_2
Increased symptom rates panels	Worst case	70	30	7	3	50
	Least case	>120	>45	10	6	>100
	Best judgment	>120	>40	8	4	100
Increased irritation symptoms	Worst case	146	85	11	63	>107
	Least case	>234	103	24	12	>149
	Best judgment	175	90	13-20	10.7	>149
Increased aggravation of asthma symptoms	Worst case	70	28	7	3	100
	Least case	>365	>100	10	4	>100
	Best judgment	>260	> 75	8	3	>100

[a] TSP = total suspended particulate, RSP = respirable size particulate, SS = suspended sulfate, SN = suspended nitrate, SO_2 = sulfur dioxide

activities. Air quality measurements from the CHAMP provide the health researcher with a description of the air pollution exposure of the human population under study. Thus, observed health effects can be related to the kind and concentration of a well-defined pollutant or pollutant mixture.

During 1974, a new CHAMP field monitoring system was installed and made operational at selected sites in Alabama, California, New York, North Carolina, and Utah. The system uses "state of the art" continuous air quality measurement systems coupled with computers to make air quality information promptly available to users. These data are transmitted at 2-hour intervals from each field station over telephone lines to RTP. Data, as received, are displayed on a screen for visual checks, and pollutant concentrations are checked by the central computer to determine whether alert conditions (excessive pollutant levels in the atmosphere) exist at any field site. Appropriate action can taken be taken to reduce the health hazard to the affected population. The data are then stored for future research use.

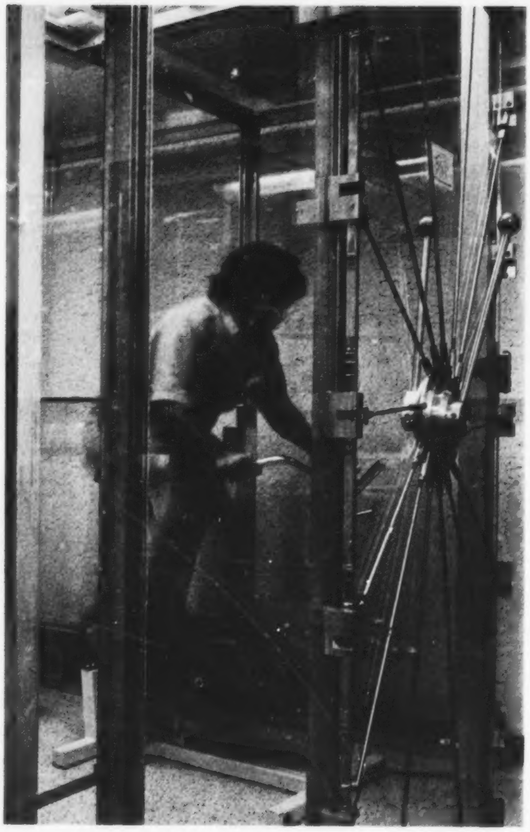
In addition, a standards laboratory was established as a repository for National Bureau of Standards and EPA reference materials, devices, and instruments for use in quality control activities.

CHAMP personnel also evaluated an airborne protein particle counter for potential use in distinguishing between anthropogenic pollutants and naturally occurring pollutants potentially detrimental to human health. The instrument, developed by the U.S. Army, was found to be compatible with the CHAMP system, and the background data thus produced may be useful for accurately ascribing certain health indices to specific pollutants or combinations of pollutants.

The CHAMP system is also being used to evaluate performance characteristics of system components and instruments provided by several manufacturers under actual field-use conditions. To improve the definition of sampling characteristics of the particulate samplers used in CHAMP, a new particulate sampling probe was designed and installed in each CHAMP field station. This new probe is being evaluated in wind tunnel tests, and its performance is being compared with the commonly used high-volume sampler.

Clinical Studies—The Clinical Studies Branch conducts pollutant effects research in several laboratories:

- A neurobehavioral laboratory in which psychophysiological effects of air pollutants are studied.
- A microbiology laboratory in which the effects of pollutants on the human immune system are investigated.
- A metabolic laboratory in which assays on blood and other biologic fluids are performed.
- A cardiopulmonary laboratory in which the effects of gaseous pollutants including ozone and nitrogen dioxide are examined.



Volunteer is asked to exercise during exposure to ozone in environmental chamber to test pollutant effects.

These laboratories, located on the campus of the University of North Carolina at Chapel Hill, became fully operational in September 1974. In addition, HSL maintains a pulmonary function laboratory at a nearby elementary school for the investigation of lung growth in children. An exercise-electrocardiography laboratory is maintained at North Carolina Memorial Hospital for investigations on the effects of pollutants, principally carbon monoxide, on cardiovascular performance.

During 1974, progress was made on two projects identified by the acronyms CLEANS (Clinical Laboratory Evaluation and Assessment of Noxious Substances) and CLEVER (Clinical Laboratory Evaluation and Validation of Epidemiological Research).

When completed, these projects will provide the Laboratory with the best research facility for clinical studies existing anywhere in the country.

Cleans—The CLEANS project consist of the construction, complete with an on-line computerized physiologic data acquisition system, of two large exposure chambers in which volunteers can be exposed for extended periods of time to the same air pollutant levels found in urban areas. These facilities will allow the Clinical Studies Branch to perform studies relating air pollutants to a wide range of physiological responses for much longer periods than could be performed in the past. Up to now, clinical studies have been performed after only brief exposures to pollutants (usually 2 to 6 hours at most). Such short-term exposures can provide only limited information on interactions between pollutants and human physiological systems. Longer-term exposures precisely simulating atmospheric conditions and involving numerous pollutants will greatly expand basic knowledge of the health effects of airborne pollution.

Each laboratory contains the most sophisticated instrumentation available for assessing the health status of the subjects. Especially important are instruments for measuring heart and lung function before, during, and after exercise. Because of the complexity of this instrumentation as well as the large amount of data acquired, most of the testing is under computer control. Medical technicians and research physicians monitor and direct the studies by interacting with the computer.

The Controlled Environmental Laboratories can operate over a wide range of temperature and humidity conditions and in either a very clean status or one programmed to simulate the desired pollution profile. Both laboratories can provide carefully controlled levels of carbon monoxide, sulfur dioxide, nitrogen dioxide, and ozone—either singly or in any combination. One of the laboratories can also provide exposure to fine particulate aerosols or nitrate and sulfate compounds. These environmental conditions are also under computer control, providing great flexibility and reliability.

Clever—Studies of the health status of populations have provided much of the available information relating environmental factors to human health. Changes in community disease patterns associated with industrialization serve as convincing indicators of the health risk accompanying technological progress. Documenting these changes in causes of death and illness is, therefore, an essential aspect of managing technical innovation and economic growth.

These studies, however, are frought with difficulties in quantitating exposure and in determining subtle alterations in health status. The traditional tools of epidemiology have successfully delineated many environmental hazards, but frequently are not sensitive enough to detect more subtle effects. It has been either logistically impossible or prohibitively expensive to use the more sophisticated modern medical diagnostic techniques in studying the epidemiology of illness caused by environmental factors. With the evolution of better non-invasive diagnostic techniques linked to computer control of the large amount of data acquired, it is now possible to greatly improve the specificity and sensitivity of population studies.

The Human Studies Laboratory has responded with the development of the CLEVER program, which will permit the verification of epidemiological research using sensitive measurements of cardiovascular and pulmonary function in the populations at risk. Two mobile laboratories, which contain the same physiologic and computerized systems used in the CLEANS program, can travel to areas in which pollutant levels are of concern and perform extensive evaluation of the health status of selected populations over an extended period of time. In addition to the standard cardio-pulmonary function measurements, the mobile laboratories will be equipped for the collection of biological samples for later analysis of pollutant burden. Delivery of the first van is expected in late 1975.

Carbon Monoxide Studies

The Laboratory has performed research on the cardiovascular effects of carbon monoxide since 1971. Those investigations have demonstrated impaired myocardial work capacity in humans at carboxyhemoglobin levels of approximately 5 to 6 percent. More importantly, it has been demonstrated that patients with coronary artery disease have diminished exercise performance at very low levels of carboxyhemoglobin (approximately 3 to 4 percent). In the past year, studies of these effects were continued to gather more information on dose-response characteristics of low levels of carbon monoxide. In addition, research projects have been inaugurated to investigate short-term effects of carbon monoxide on various clotting factors and blood lipids in human volunteers.

Studies completed in 1974 demonstrated decreased physical work performance at levels of carboxyhemoglobin of 5 percent in healthy young men. Other investigations in dogs showed worsening myocardial infarction as carboxyhemoglobin levels rose above 5 percent. These studies will be expanded in 1975.

At present considerable controversy exists as to the effects of low levels of carbon monoxide on the human central nervous system. During 1974, the neurobehavioral laboratory conducted pilot studies on psychophysiological tasks using noise as a stress agent. When the carbon monoxide exposure chamber becomes operational, the laboratory will conduct further experiments to elucidate effects of carbon monoxide on human behavior. Plans are underway to study interactive effects of carbon monoxide with other stress agents, including noise and alcohol.

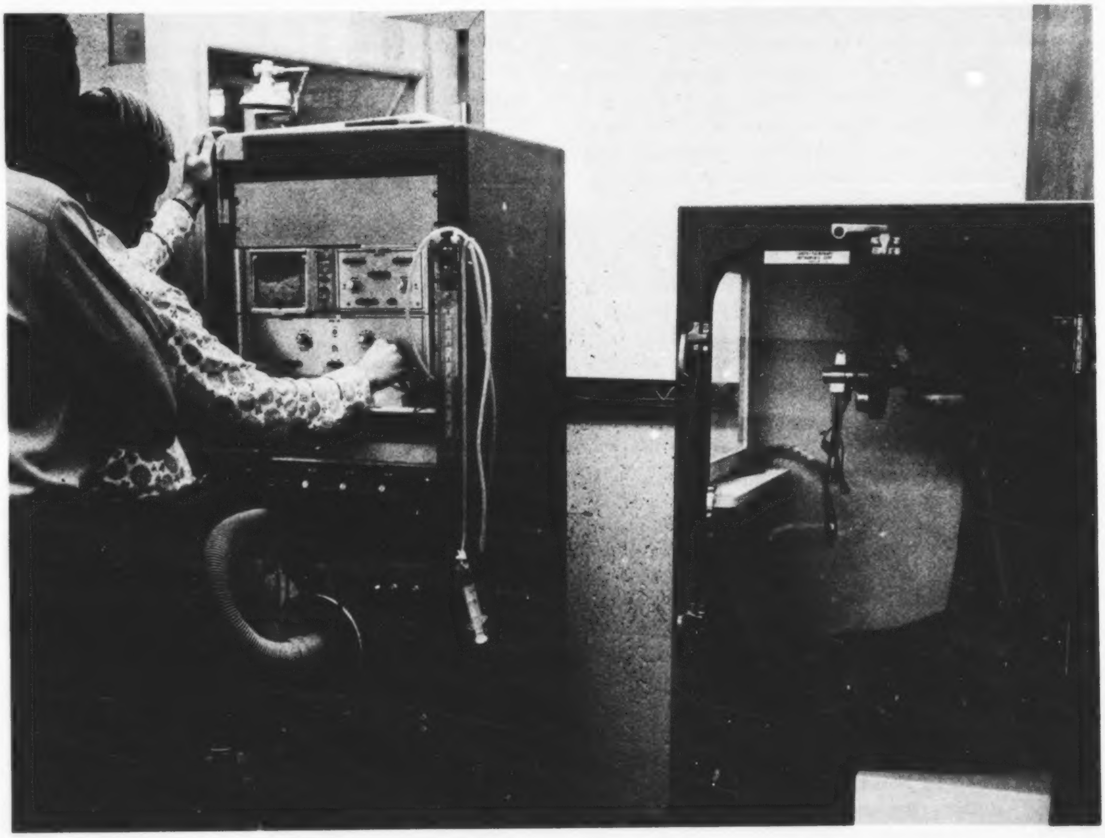
Ozone and Nitrogen Oxides Studies

With completion of the plexiglass exposure chamber in the clinical laboratories in the spring of 1974, the Laboratory began studies on the effects of ozone and nitrogen dioxide on cardiovascular performance and cellular function. Initial studies concentrated on effects of ozone on pulmonary performance and cytogenetic damage to circulating lymphocytes. Studies also included evaluation of phagocytic function and lymphocyte transformation. The latter studies are designed to serve as pilot ventures in assessing the impact of oxidant pollution on those defense mechanisms.

Pulmonary Studies in Children

Since 1972, a study has been underway to characterize those parameters of growth that best define growth in lung function. This study is being performed in Chapel Hill, N.C., where ambient air pollution is low. It is anticipated that information from this study will form a basis for learning about possible deleterious effects of pollution on lung growth. Such a study will be feasible in more polluted areas in the near future by using the CLEVER mobile laboratories.

In addition to identifying those factors that best define lung growth, the study is investigating the effects of viral and bacterial infections on pulmonary



Pulmonary function of volunteer exposed to ozone in laboratory is tested to evaluate pollutant effects.

performance. This study also may be expanded using the CLEVER facility to analyze interactive effects of pollution and microbial agents on lung function in children. Results from 18 months of study have undergone preliminary analysis, and a full report will be written in 1975.

Other Studies

During 1974, a joint contract with the University of Maryland Medical School and Johns Hopkins Medical School investigating effects of ozone on pulmonary function in normal subjects was completed. The exposures took place in an environmental chamber at the University of Maryland Medical School. Results have undergone early analysis and will be useful in better characterizing pulmonary effects of ozone exposure. Results from grant-supported pulmonary research at Ranchos Los Amigos Hospital in California have also provided preliminary information on effects of ozone and nitrogen oxides on pulmonary function.

Other contracts initiated during 1974 are designed to study effects of nitrogen dioxide on subjects with preexisting pulmonary disease, to study interactive effects of heat stress and oxidant pollutants on cardiopulmonary performance in humans, to support research on cytogenetic effects of oxidants, and to study effects of sulfur dioxide and various sulfates on lung function.

LEGISLATIVE MANDATE

HSL's research program is designed to meet the legislative mandate expressed in Section 103 of the Clean Air Act and in Section 241 of the public Health Service Act. Specific sections of the Acts are shown below followed by brief descriptions of the types of actions taken by HSL in support of the mandates.

> **"RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES**
>
> **"Sec. 103. (f) In carrying out research pursuant to this Act, the Administrator shall give special emphasis to research on the short- and long-term effects of air pollutants on public health and welfare. In the furtherance of such research, he shall conduct an accelerated research program—**
>
> **"(A) to improve knowledge of the contribution of air pollutants to the occurence of adverse effects of health, including, but not limited to, behavioral, physiological, toxicological, and biochemical effects; and**
>
> **"(B) to improve knowledge of the short- and long-term effects of air pollutants on welfare.**
>
> **"(2) In carrying out the provisions of this subsection the Administrator may—**
>
> **"(A) conduct epidemiological studies of the effects of air pollutants on mortality and morbidity;**
>
> **"(B) conduct clinical and laboratory studies on the immunologic, biochemical, physiological, and the toxicological effects including carcinogenic, teratogenic, and mutagenic effects of air pollutants . . ."**

In support of Section 103, HSL develops and conducts studies designed to define relationships between specific undesirable health effects and environmental pollutants, either individually or in combination. This research includes biochemical laboratory studies, clinical studies on human subjects, and epidemiological studies of human populations. Knowledge of the effects of short- and long-term exposure to environmental pollutants provides a basis for establishing national environmental or emission standards for those pollutants or source categories that endanger human health or welfare. In addition, the HSL research program is designed to evaluate the health benefits of improved air quality resulting from the establishment of emission standards. This program is also concerned with the decrement in health resulting from any future relaxation in air quality standards in response to the energy crisis. Analysis of the economic costs resulting from adverse health effects of pollution is an integral part of the HSL program.

Epidemiologic studies on the effect of radiation on humans come under the broad mandate of Section 241 of the Public Health Service Act, which is quoted in part below.

> **"THE PUBLIC HEALTH SERVICE ACT"**
>
> **"Sec. 241. Research and investigations generally . . . "The Surgeon shall conduct in the Service, and encourage, cooperate with, and render assistance to other appropriate public authorities, scientific institutions, and scientists in the conduct of, and promote the coordination of, research, investigations, experiments, demonstrations, and studies relating to the causes, diagnosis, treatment, control, and prevention of physical and mental diseases and impairment of man . . ."**

Under the broad mandate of Section 241, HSL studies the effects of ionizing radiation exposure on humans in cooperation with the Atomic Bomb Casuality Commission research program in Japan. HSL places major emphasis on evaluating the risk of adverse irreversible biological effects from exposure to various levels of different pollutants and in delineating the time lapse between exposure and disease (latent effects). Other studies conducted by the laboratory are concerned with the effects of non-ionizing radiations to which the general population is exposed. HSL resources committed in support of these Acts are shown in Table 10.

Table 10. SUMMARY OF RESOURCES FOR HUMAN STUDIES LABORATORY FOR FISCAL YEAR 1975

Category	Funds, $\$10^3$
Clean Air Act, Section 103	11,231
Public Health Service Act, Section 241	389
Federal Water Pollution Control Act, Section 104(b) (3)	547
Total[a]	12,167

[a] Total does not include $3.3 million of special energy appropriations.

Experimental Biology Laboratory

OVERVIEW OF EBL MISSION

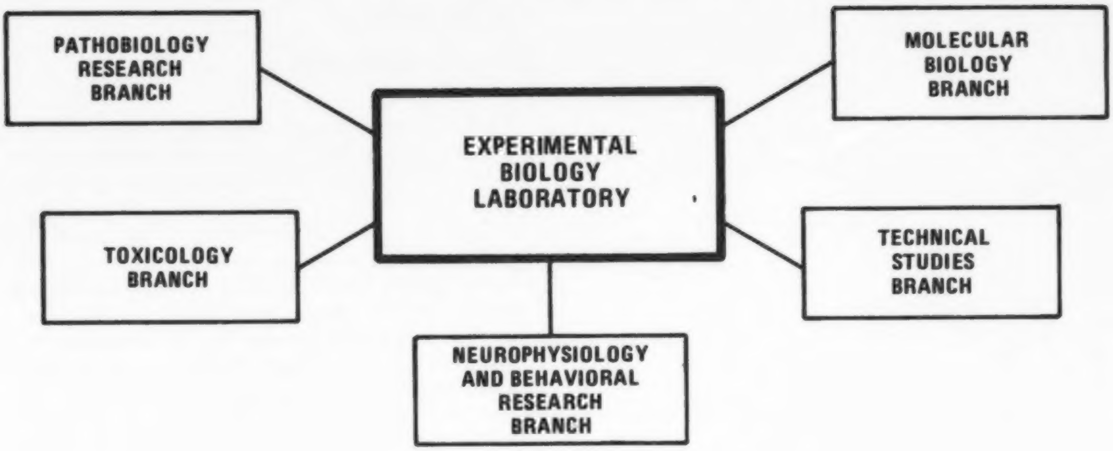
Experimental Biology Laboratory research is directed toward studies relevant to the development of environmental standards for the protection of human health and welfare, particularly as such standards relate to gaseous and particulate air pollutants, to ionizing and nonionizing radiation, and to interactions among pollutants. Studies using laboratory animals or biological preparations complement human epidemiological and clinical programs by validating data from human studies, providing clues to new human studies, developing toxicity data for extensions to humans, and indicating the potential harmful effects of new pollutants. These studies require the coordinated contribution of chemists, engineers, and representatives of a wide variety of biological disciplines. The Laboratory possesses particular expertise in the areas of animal toxicology, radiation biology, neurobiology, and microwave engineering.

ORGANIZATION

The Office of the Director ensures integrated application of the multi-disciplinary expertise available within the five branches in research projects designed to develop information pertinent to formulation and revision of environmental quality criteria in support of human health studies.

The Pathobiology Research Branch is primarily concerned with the investigation of air pollutants as they relate to acute and chronic respiratory disease and pulmonary carcinogenesis, and as they affect an organism's mechanisms of defense against infectious agents, using whole animal and *in vitro* model systems. Particular emphasis is given to interactions between chemical, biological, and physical insults. The Branch also has responsibility for development of rapid throughput *in vitro* screening systems for determining the relative toxicity of gaseous and particulate air pollutants.

The Toxicology Branch investigates the gross teratologic, reproductive, developmental, and genetic effects of a variety of environmental pollutants, together with late effects such as tumor production and life span shortening. Originally concerned largely with the toxicology of radioactive materials, the Branch has extended its activities to studies of the biological effects of nonionizing radiation and of the interactions between radiation and other existing environmental pollutants.


PATHOBIOLOGY RESEARCH BRANCH
MOLECULAR BIOLOGY BRANCH
EXPERIMENTAL BIOLOGY LABORATORY
TOXICOLOGY BRANCH
TECHNICAL STUDIES BRANCH
NEUROPHYSIOLOGY AND BEHAVIORAL RESEARCH BRANCH

The Molecular Biology Branch's principal interest is the interaction of radio frequency and microwave radiation with biological systems at the subcellular and molecular level, with particular attention being given to effects on the genetic material and other macromolecules and on the organelle and cell membranes. The Branch's expertise in microbiology, biochemistry, and physical chemistry and in electron spin resonance techniques is also being applied to studies on the toxicity of tritium and heavy metals and on the extrapulmonary toxicity of photochemical oxidants.

The Neurophysiology and Behavioral Research Branch investigates possible adverse effects of environmental contaminants on the nervous system in animal models and develops research methodology in the area of neurobiology applicable to the study of human populations. The members of the Branch function as an interdisciplinary team to study responses of behavioral, electrophysiological, neurohumoral, and related physiological parameters to exposure to chemical and physical stressors including air pollutants, pesticides, and ionizing and non-ionizing radiation.

The Technical Studies Branch provides support to the Laboratory through the development and maintenance of equipment and instrumentation necessary for biological effects research, particularly in the area of electromagnetic non-ionizing radiation. The Branch also coordinates the Laboratory's computer services and provides computer programs to support biological activities. The Branch conducts research in the dosimetry of non-ionizing radiation and the application of dosimetric techniques to biological studies.

PHYSICAL FACILITIES

The Laboratory possesses facilities for exposure of laboratory animals (via inhalation) to gaseous materials and aerosols under controlled conditions of air flow, temperature, and humidity and for exposure (via inhalation and whole-body exposure) to radioactive gases (currently krypton-85) over long periods under beta-infinite cloud conditions.

Facilities that permit exposure to a range of radio and radar frequency radiations are available or under construction. These facilities include two large anechoic chambers for use at S- and X-band frequencies, both with environmental control systems; a strip-line facility for whole-body exposures of small mammals over the VHF, TV, and UHF ranges; and numerous custom-built airline systems for irradiation of cellular, subcellular, and molecular preparations at frequencies upward from 200 MHz.

Electrophysiological recording instrumentation and behavioral testing chambers (housed in RF-shielded and/or sound-attenuated rooms), with associated laboratory computers, are available for neurobiological studies.

For measurement of concentrations of paramagnetic species and free radicals, an electron spin resonance spectrometer with a 9-inch electromagnet and a double cavity is available. The system also includes frequency measuring equipment for precise g-value determinations to characterize and identify unknown species. Additionally, the associated variable temperature unit permits determination of free radical reaction rates and matrix trapping ability from 80°K to 370°K.

MAJOR PROGRAM AREAS

Air Pollutants

A comprehensive biomedical study is being made for the purpose of evaluating the actual and potential biological effect of the major air pollutant gases and particulates in biological models. Agents emphasized during the past year include sulfur dioxide, sulfuric acid and sulfates, ozone, nitrogen dioxide, metals, and organics. This work is carried on through an integrated program by in-house and contract efforts employing whole animal and *in vitro* models, and emphasizes interacting systems where possible.

The influence of sulfuric acid, sulfur dioxide, and various sulfates is being studied in isolated cells, perfused lung, and whole animals. A dynamic reaction chamber has been constructed to furnish exposure facilities simulating natural atmospheres. Inhalation of sulfuric acid (H_2SO_4) aerosol in guinea pigs caused a 50 percent increase in the total deposition of inhaled radioactive particles and a proximal shift in the regional deposition pattern to the nasopharnyx, suggesting a pathophysiologic rationale for the high sensitivity of asthmatics to sulfur oxides. The respiratory clearance of non-viable radioactive streptococcal aerosols (2.6 μm MMAD) from the nose and lung was reduced by acute, short-term exposure to H_2SO_4. Neither aerosol concentration had any effect on the rate of reduction of viable streptococci from the lung or nose of mice. Thus, this and the preceding study suggest that H_2SO_4 acts principally on the airways of the respiratory tract and not on the alveolar region of the lung. Preliminary studies indicate that chronic respiratory infection (Bordetella pertussis) can be enhanced by inhalation of H_2SO_4.

Ozone has been shown to increase the pentobarbital sleeping time in mice. This is further indication that ozone may exert extra-pulmonary effects. Work has continued on establishing dose-response relationships for NO_2. Indications are that concentration is more important than duration of exposure in eliciting toxic results and that effects from intermittent exposure may be as toxic, on a time basis, as continuous exposure.

Studies of the relative toxicity of mercury, lead, cadmium, zinc, chromium, nickel, manganese, and sulfates of various cations have been carried on in *in vitro* systems employing pulmonary macrophages and human fibroblasts. The influence of these agents on cellular viability and on alterations in membrane and cellular kinetics is being studied. Exposure to Ni^{2+}, Mn^{2+}, Cd^{2+}, and Cr^{3+} reduced phagocytic activity of alveolar macrophages. Interestingly, a concentration of VO_3^- that killed and lysed macropages had no effect on phagocytosis; whereas, concentrations of Ni^{2+} that had no effect on macrophage viability or lysis caused severe phagocytic reductions. Coordinated studies employing *in vivo* methods are also being carried out to investigate the parameters that alter host defense mechanisms and that affect deposition and clearance of trace metals. Inhaled cadmium has been found to enhance the pathogenicity of inhaled microorganisms.

Pulmonary cocarcinogenesis studies use intratracheal instillation into Syrian hamsters of a standard carcinogen (benzo[a] pyrene) alone or in combination with metallic oxides. Chemically characterized particulate materials collected from the ambient air are also being studied in this animal model. The interaction of particulate material and noxious gases (NO_2 and O_3) in the induction and/or alteration of pulmonary neoplastic response in animals is being investigated as well.

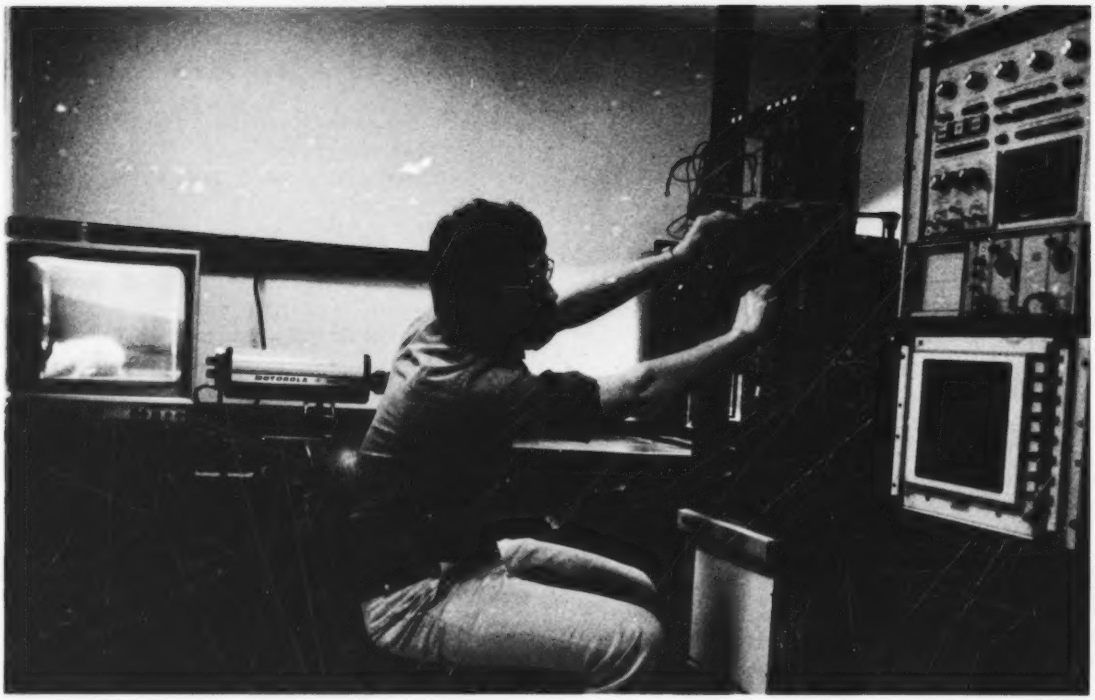
An *in vitro* toxicity screening system using rabbit alveolar macrophages is now fully developed for estimating the relative toxicity of soluble and insoluble particulate air pollutants. Complete concentration-response data on cell viability, cell number, or total protein, ATP, and phagocytic activity can be obtained for any test material using the number of alveolar macrophages recoverable from a single rabbit. The system is currently being employed to estimate the relative toxicity of stationary source air samples. An additional system has been developed which employs rapidly dividing human lung fibroblasts to test for compounds that inhibit cellular biosynthetic activities. A preferential inhibition of DNA synthesis by relatively low concentrations of tetravalent platinum was detected using the human fibroblast system. Pentavalent vanadium and divalent cadmium were also determined to be highly cytotoxic. Facilities are essentially complete to begin implementation of *in vitro* test systems for detection of potential carcinogens. Tests for chemically induced neoplastic transformation will complement ongoing systems for toxicity testing *in vitro.*

Ionizing Radiation

Programs in radiation health effects research are presently confined to tritium and krypton-85, two major effluents from the reprocessing of nuclear fuel.

Tritium—During the reporting period, two studies have been completed; one on the production of tumors and the effects on life span of chronic exposure to tritiated water (HTO) throughout gestation, and the other on the relative sensitivity of different aged populations to chronic HTO exposure.

In the first study, Sprague-Dawley rats were continuously exposed from conception through birth to tritiated water (HTO). Intrauterine exposures to calculated cumulative doses up to 66 rads had no



Patterned behavior in rats exposed to pollutants is analyzed using closed circuit television coupled with computer methodology.

significant effects on either sex with respect to life span, overall neoplasia incidence, the incidence rate, or the onset of mammary fibroadenomas. Females exposed to 330 or 660 rads were sterile and had lower incidence rates of mammary fibroadenomas than controls, and at 660 rads exhibited a lower incidence of overall neoplasia and reduced mean life span. Sterile male offspring had reduced mean life span after irradiation at 660 rads. Regardless of dose group, females had significantly higher incidences of neoplasia and longer life spans than males.

In the second study, rats were continuously exposed to 10 μCi HTO/ml of body water (approximately 3 rads per day) for 42-day periods beginning variously at conception, birth, and 42 or 74 days postnatally. Assessment of the relative sensitivity of the different ages to chronic HTO exposure of 126 rads was in terms of reproductive performance, central nervous neurotransmitter, and follicle-stimulating hormone levels. At 49 days of age, the beginning of sexual maturity in the rat, testes weights and sperm counts were significantly depressed in animals exposed from conception or birth. Ovary weight was not affected by exposure from conception but was significantly reduced when the exposure began at birth. Mating of exposed males and females began at 120 days of age and continued through the production of three successive litters by each pair; this was followed by sacrifice of that dam at 200 days of age upon delivery of the last litter. The mean litter size for the three litters was significantly reduced, and the resorptions increased in the last litter for those animals exposed from conception. At 49 days of age, norepinephrine concentration was significantly increased, and dopamine concentration was unchanged in male animals exposed from conception but not birth. At 300 days of age, a reversal had occurred with both neurotransmitter levels being significantly decreased in animals exposed from conception or birth. Follicle-stimulating hormone levels in the pituitaries of adult males were significantly increased only in those animals exposed from 42 or 74 days postnatally.

It had previously been determined, in studies involving the continuous exposure of rats to HTO from conception through production of the third (F_2) generation, that lifetime parental exposure produced effects in the F_2 generation at levels 10 to 100 times lower than those required for the same effects after *in utero* exposure alone. Statistically significant reductions in the relative brain weights of neonates were noted at doses as low as 20 times the MPC_W for individuals in the population. It has now been shown that these changes are accompanied by functional deficits. The age of development of the startle reflex, eye opening, and the righting reflex was delayed. The righting reflex was the most sensitive of the three parameters, being delayed 2 days at the highest exposure. These same animals, when tested in a residential maze at 120 days of age, showed a dose-related reduction in spontaneous motor activity. Correlated with this was a slowing of the spontaneous anesthetized EEG, i.e., an increased abundance of slow ("Delta") waves with decreased abundance of both "Alpha" and "Beta" frequencies.

Under the sponsorship of the Special Foreign Currency Program, EBL serves as the responsible U.S. organization for tritium research being conducted by the Central Laboratory for Radiological Protection in Warsaw, Poland. The emphasis in the Polish studies is on the transfer of HTO from soil to plants, the incorporation of tritium into specific amino acids, the effects on rabbits of consumption of totally tritiated diets, the uptake, distribution, and retention of organically bound tritium, and the dose-response relation for the production of chromosome aberrations in human lymphocytes by HTO.

Krypton-85—Research into the physiological behavior and radiation effects of krypton-85 is designed to provide data for a realistic assessment of the hazards of exposure to this noble gas.

Investigations are being conducted using animals exposed via inhalation or whole body in beta-infinite cloud conditions. Previously completed studies using inhalation exposure include: (1() determination of *in vivo* kinetic parameters and partition coefficients for the whole guinea pig; (2) determination of equilibrium concentrations of ^{85}Kr in blood and 22 organs or tissues of guinea pigs breathing known concentrations of ^{85}Kr; and (3) determination of the median lethal exposure in guinea pigs for ^{85}Kr administered by inhalation. Inhalation experiments slated for completion in 1975 include study of hematopoietic effects and pathology of serially sacrificed guinea pigs receiving the median lethal exposure.

Guinea pigs exposed to ^{85}Kr in beta-infinite geometry with fur surface doses of up to 20,000 rad all survived the acute post-exposure period and are being observed for life-span shortening, lung effects, and appearance of skin tumors.

Nonionizing Radiation

EBL's programs in nonionizing radiation research are conducted as part of a multi-agency "Program for Control of Electromagnetic Pollution of the Environment: The Assessment of Biological Hazards of Nonionizing Electromagnetic Radiation" coordinated by the Office of Telecommunications Policy.

Animal models (whole animals and cellular, subcellular, or molecular preparations as appropriate) are used to investigate potential damage—including genetic, biochemical, immunological, teratological, and neurobiological effects—from exposure to radio and microwave frequencies similar to those found in the environment. Studies are designed to identify potential harmful effects, to establish the exposure levels at which these effects are elicited, and to delineate the mechanisms of physical alterations. These studies will provide a data base for the promulgation of standards governing the exposure of the population to nonionizing radiation.

The possibility of transient as well as permanent effects of microwave radiation on macromolecular systems has been investigated using a crossed-beam apparatus (essentially a waveguide irradiation system integrated with a UV spectrophotometer). The enzyme ribonuclease and mononucleotide substrate analogs have been used to investigate whether radiation at 1.70 or 2.45 GHz interferes with the binding of the smaller molecules to the protein. No differences have been noted between samples under irradiation and those not irradiated. In addition, enzymes from soluble, microsomal, and mitochondrial cellular fractions were irradiated at 2.45 GHz in the crossed-beam apparatus, but no significant differences were observed between the specific activity of control and irradiated samples.

A microwave irradiation system consisting principally of a coaxial airline and an oxygen electrode cell was developed to rapidly monitor the respiratory activity of mitochondria after exposure to microwaves. The mitochondria are irradiated in the airline while biochemically active, i.e., at 30°C, and respiration is measured with the oxygen electrode as the suspension exits the coaxial airline. The system will be used to study the effect of 2 to 4 GHz electromagnetic radiation on the energy-conserving reactions (electron transport and oxidative phosphorylation) which occur in mitochondria.

In a study designed to detect differential effects of electromagnetic radiation on the bacterium *E. coli* grown in media containing particular carbon and nitrogen substrates, no growth changes were found that could not be attributed to temperature differences between controls and samples irradiated at 1.7 and 2.45 GHz. In addition, this cellular system was used to examine the mutagenic effect of microwaves. The results show no differences in the mutation frequency of unirradiated bacteria and bacteria irradiated at these two frequencies.

Several reports in the literature suggest that microwave radiation alters the immune response of animals and cellular preparations. Such effects, if real, are of great potential significance to the general public. Consequently, the effect of microwaves on the membrane phenomenon called phagocytosis was studied in polymorphonuclear leukocytes (neutrophils). Neutrophils from guinea pigs were irradiated *in vitro* with 2.45 GHz (continuous wave) or with 9.0 GHz (pulsed) radiation either before or during challenge with polystyrene balls, which were used to induce phagocytosis. No differences in induction which could not be attributed to generalized heating of the cells could be detected between the irradiated and the control samples. Additionally, studies were initiated to examine both the capacity of leukocytes to phagocytize foreign materials and the capacity of other types of cells to respond to antigenic stimulation following microwave irradiation.

Teratologic investigations were also conducted. Bred mice were exposed to 2.45 GHz microwave radiation at 14 mW/cm^2 for 100 minutes per day from days 1 through 17 of pregnancy, at which time they were killed, and their fetuses examined for weight, sex, and gross morphology. The litters of 73 control and 62 treated mice were examined. Approximately 150 fetuses have yet to be fully examined. In the interim, the results show no statistically significant effects in: the number of pregnancies, the size of the litter, the ratio of live to dead fetuses, and the weight of live fetuses. However, when fetuses were examined for gross anomalies, three fetuses (one each from three treated litters) had encephaloceles; none were found in control litters. The χ^2 of the incidence of litters with any encephaloceles was significant ($p < 0.05$).

In a pilot study to a series of experiments designed to examine effects on the central nervous system of prolonged exposure to microwave radiation, neonate rats were exposed to 9 GHz microwave irradiation at 3 or 10 mW/cm^2, for 2 hours per day, from days 1 through 21 of age. The time-course of development of startle and righting reflexes was not altered by treatment, nor was the age of eye opening. A 5-minute motor activity measurement at intervals from days 9 through 21 of age was suggestive of irradiation-induced hypoactivity. EEG and visual-evoked responses were measured at 30 days of age. The mean frequency of the spontaneous EEG was not altered by exposure. However, the amplitude of the primary visual evoked response was suppressed. Continuing studies on these animals will include measures of learning, memory, and residential-maze motor activity.

Neurotoxicology of Pesticides

This program, conducted in collaboration with the Pesticides and Toxic Substances Effects Laboratory, is directed toward evaluating the effects of pesticidal chemicals on CNS function including EEG, neuroendocrine activity, neurochemistry, and behavior. In addition, the program develops methodology for fast through-put, neurotoxicity screening.

A representative series of carbamate pesticides is being studied for both direct (after 1 month of daily feeding) and residual (1 month after removal of pesticide) neurobiologic effects in young and mature rats of both sexes. Preliminary analyses show pesticide-induced changes in frequency distribution may be age-dependent and are not qualitatively the same for each of the carbamates under study. For example, young females treated with Ferbam show no changes in the percentage abundance of slow waves in their EEG. However, when treated with carbaryl, a clear-cut increase in slow-wave abundance is evident. Interestingly, Ferbam also results in a slower and more variable rate of contractions in intestinal smooth muscle.

Considerable effort has been placed on development of usable radioimmunoassay (RIA) procedures for endocrine and neuroendocrine studies. At the present time, RIA techniques exist for the assay of prolactin, FSH, GH, and cortisol.

EEG recordings from rodents and primates exposed to pesticides provide material for the development of computer methodology for rapid and reproducible evaluation of pesticide-induced changes in the spontaneous EEG. In addition, methodology is being developed for the extraction of deep-brain-structure electrical activity from the EEG as recorded from the scalp.

Multiple, Coexisting Environmental Stressors

During 1974 a study of the long-term effects of continuous exposure to lead and tritium was completed. These two pollutants possess characteristics which suggested that they might act synergistically. Both are placentally transferred; the embryo and fetus are particularly sensitive to both, and exposure to either can result in reduced litter size, stunted neonates, sterility, and mental retardation.

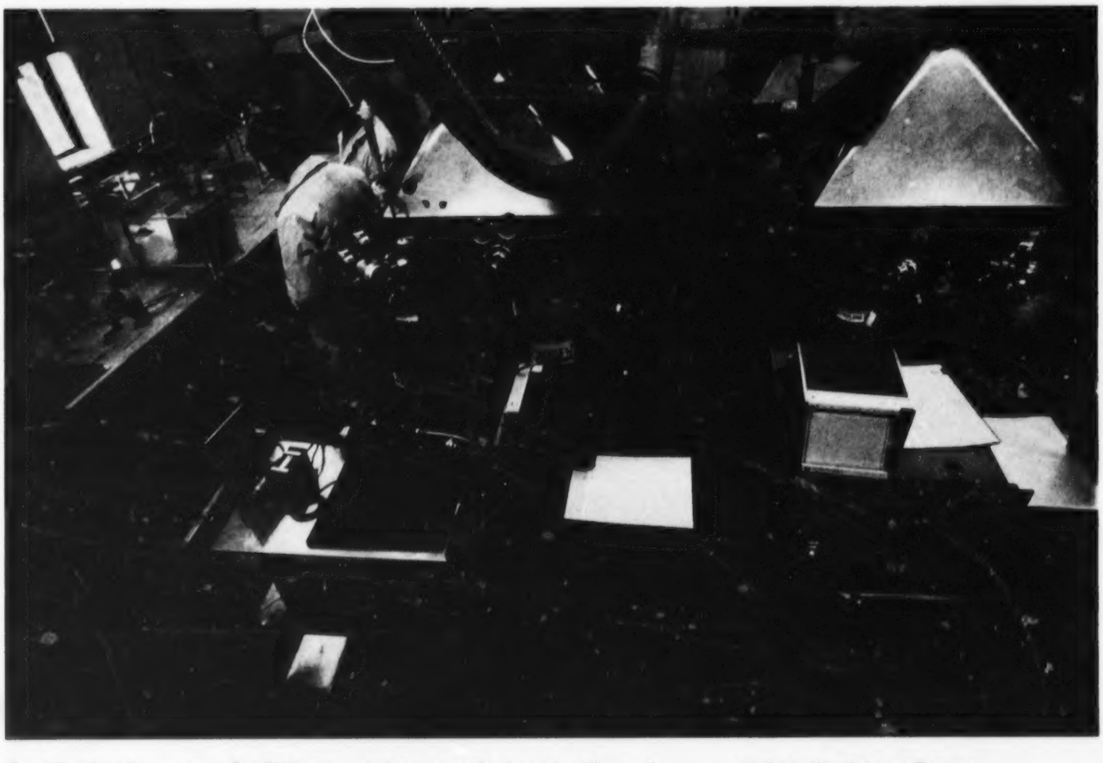
Rats were exposed continuously from conception, through the production of a new generation, to the adulthood of the F_2 generation. Lead levels of 5 and 50 ppm (100 and 1000 times the Public Health Service standards for drinking water, respectively) and tritium levels that are 2 to 200 times the standard (MPCw) for individuals in the general population were used in the study.

A synopsis of the results of the 12-cell matrix experiment is as follows: No significant differences in body weight occurred in the F_1 generation from weaning through 180 days under any exposure condition. Tritium exposure had no effect on the reproductive performance of the F_1 generation; thus, all tritium groups were combined into the appropriate lead exposure groups. There was a suggestion that the mean number of ovulations per pregnancy increased with lead exposure. Further, in animals with one or more pre-implantation deaths, the mean number of deaths per litter increased with increasing lead exposure. No effects were seen on litter size, resorptions, sex ratio, or the weight of F_2 neonates.

The percent body weight of a number of F_2 neonatal organs was investigated. The neonatal brain alone demonstrated dose-related reductions with either lead or tritium exposures. Exposure to the combined insults had a lesser effect than either insult alone, suggesting that for this parameter they appear to be antagonistic.

Since tritium did not influence the lead concentrations of any of the organs assessed at any age, all tritium data were combined into their respective lead dose groups. The ratio of maternal to fetal blood lead was 1.4 and was constant throughout the lead-exposure groups. Lead levels were exposure-related in neonatal blood, liver, and lung, but no significant accumulation of lead over control values occurred in neonatal kidney, brain, heart, or spleen at either dose level. Adult tissue concentrations had the expected ranking of critical organs, i.e., bone > kidney > liver. Testes of exposed males did not concentrate lead beyond control values. No significant differences were seen in the organ lead levels from one generation to the next.

At levels of 5 and 50 ppm of lead in the drinking water, the age of onset of the righting reflex of newborn rats was delayed. The age of appearance of the startle reflex and eye opening were delayed at the higher dose only. Thus, the righting reflex, which represents a higher level of complexity of neuromuscular development, is affected by lower lead-exposure levels. Both lead-exposure levels also reduced spontaneous, exploratory motor activity in residential maze tests at 120 days of age. Interestingly, tritium (which also delayed neuromuscular development and resulted in hypoactivity) and lead in combination, antagonized each other. Although lead alone did not alter the frequency distribution of the spontaneous EEG, it did antagonize the tritium effect described above. Study of these animals' social and patterned behavior is continuing.



Small animal exposure facilities are used to test the health effect of gaseous and particulate pollutants.

LEGISLATIVE MANDATE

EBL's programs support Section 103 of the Clean Air Act and Section 241 of the Public Health Service Act. The relevant sections of the Acts are shown below followed by brief descriptions of the types of actions taken by EBL to support them.

> **"RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES**
>
> **"Sec. 103. (f) (1) In carrying out research pursuant to the Act, the Administrator shall give special emphasis to research on the short- and long-term effects of air pollutants on public health and welfare. In the furtherance of such research, he shall conduct an accelerated program—**
>
> **"(A) to improve knowledge of the contribution of air pollutants to the adverse effects of health, including, but not limited to, behavioral, physiological, toxicological, and biochemical effects; and**
>
> **"(B) to improve knowledge of the short- and long-term effects of air pollutants on welfare.**
>
> **"(2) In carrying out the provisions of this subsection the Administrator may—**
>
> **"(A) conduct epidemiological studies of the effects of air pollutants on mortality and morbidity;**
>
> **"(B) conduct clinical and laboratory studies on the immunologic, biochemical, physiological, and the toxicological effects including carcinogenic, teratogenic, and mutagenic effects of air pollutants; . . . ."**

EBL programs in support of Section 103 include studies on the effects of the regulated pollutants (ozone, nitrogen oxides, sulfur oxides, and particulates) and the non-regulated pollutants (particulate sulfate and nitrate, fine particulates from industrial sources, trace metals, etc.) using appropriate whole animal, organ, cellular, or sub-cellular models. Particular emphasis has been given to the effects of pollutants on pulmonary defense mechanisms and pulmonary carcinogenesis and to the influence of interactions between coexisting pollutants and various physical factors upon these pulmonary responses. The potential mutagenicity of photochemical oxidants is also under investigation. Programs are under development to examine the effects of prenatal and neonatal, as well as adult, exposure to photochemical oxidants and carbon monoxide upon subsequent growth and development (including development of behavioral patterns).

> **"THE PUBLIC HEALTH SERVICE ACT**
>
> **"Sec. 241. Research and investigations generally**
>
> **"The Surgeon General shall conduct in the Service, and encourage, cooperate with, and render assistance to other appropriate public authorities, scientific institutions, and scientists in the conduct of, and promote the coordination of, research, investigations, experiments, demonstrations, and studies relating to the causes, diagnosis, treatment, control, and prevention of physical and mental diseases and impairment of man, including water purification, sewage treatment, and pollution of lakes and streams . . . ."**

The "causes . . . of . . . diseases" cited in Public Health Service Act Section 241 include ionizing and non-ionizing radiation. The responsibility to provide Federal guidance on all radiation matters affecting health and the authority to establish environmental standards for the protection of the general environment from radioactive material rests with EPA. EBL programs related to ionizing radiation are centered on tritium and krypton-85, two of the major effluents from nuclear fuel reprocessing plants, and are designed to provide a more secure data base for prediction of potential health effects than is currently available. The Laboratory also conducts an extensive program on the health effects of electromagnetic non-ionizing radiation. Emphasis is placed on the potential mutagenic, teratogenic, and neurobiological effects—and mechanisms of interaction at the cellular and subcellular level—of radiations of frequencies ranging from 500 megahertz (MHz) to 10 gigahertz (GHz). Table 11 presents a summary of resources employed by EBL during Fiscal Year 1974.

Table 11. SUMMARY OF RESOURCES FOR EXPERIMENTAL BIOLOGY LABORATORY FOR FISCAL YEAR 1975

Category	Funds, $\$10^3$
Clean Air Act, Section 103	2,160
Public Health Service Act, Section 241	1,450
Federal Environmental Pesticide Control Act, Section 20	85
Total[a]	3,695

[a] Does not include $1.94 million of special energy appropriations.

Pesticides and Toxic Substances Effects Laboratory

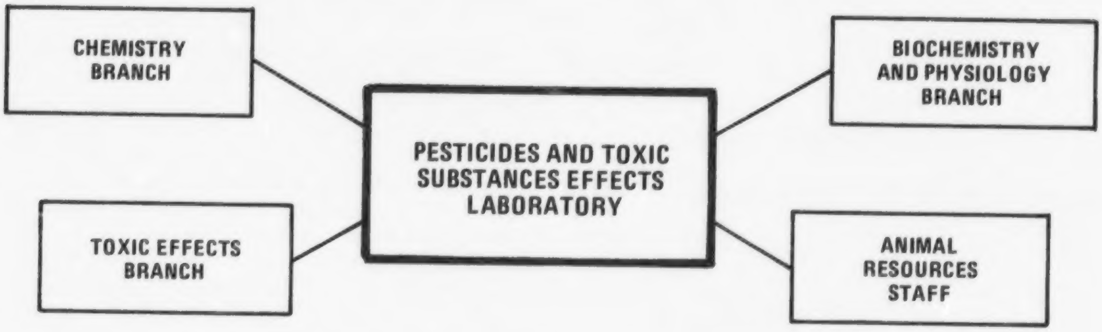
OVERVIEW OF PTSEL MISSION

EPA's Office of Pesticide Programs is responsible for registering pesticides for use in the U.S. and for establishing tolerance levels of pesticide residues in or on raw agricultural products. All research conducted at ORD-RTP's Pesticides and Toxic Substances Effects Laboratory (PTSEL) is designed to provide a foundation for decisions made by EPA's registration offices. Data from acute, subacute, and chronic studies in laboratory animals and examinations of occupationally exposed individuals are used to augment the basic scientific knowledge that establishes the need for continued registration of pesticides or toxic substances in use in the U.S. Analytical chemistry research is directed toward the detection of toxicants in biological samples.

Included among the basic research goals and objectives of the PTSEL is the development, evaluation, and application of instrumental techniques in a program of basic and applied research in two general areas:

- Elucidation of the mechanism of action of pesticides and their metabolic products in a variety of biological substrates and in appropriate model systems. This research is accomplished through the use of magnetic resonance and spectrophotometric techniques.
- Development of a methodology and capability for the isolation, detection, characterization, identification, confirmation, and/or quantitation of pesticide residues, metabolites, and other chemical contaminants in human, animal, and environmental media. This research is accomplished, in part, through the use of magnetic and quadrupole resonance methods, spectrophotometric techniques (including infrared, ultraviolet, and atomic absorption), gas and liquid chromatography, and combinations of chromatographic separations with sensitive and specific detection systems and low- and high-resolution mass spectrometry.

Newer and more comprehensive analytical methods for the determination of residues of pesticides and their metabolic products are being developed to permit effective monitoring of the total environment. The continued development of analytical methods in pesticidal research is a necessary component of efforts to minimize human and animal exposure and to preserve the quality of the environment.


CHEMISTRY BRANCH
TOXIC EFFECTS BRANCH
PESTICIDES AND TOXIC SUBSTANCES EFFECTS LABORATORY
BIOCHEMISTRY AND PHYSIOLOGY BRANCH
ANIMAL RESOURCES STAFF

ORGANIZATION

The Pesticides and Toxic Substances Effects Laboratory consists of two main functioning laboratory groups: biological and physical.

Physical research is conducted by the Chemistry Branch, which is responsible both for the study of the metabolism of pesticides, their metabolites, and residual products in a variety of biological and environmental substrates and for the development of methodology for the determination of pesticide residues. In addition, quality assurance for methods used by EPA and other laboratories is maintained through the use of a standard reference repository and an instrumental workshop for maintenance of equipment.

Biological research is conducted in two branches: the Toxic Effects Branch and the Biochemistry and Physiology Branch. The Toxic Effects Branch is responsible for investigating short- and long-term effects (including reproductive hazards) of pesticides. Teratogenesis and mutagenesis potentials of pesticides are principally addressed in this area as are acute, subacute, and chronic studies on laboratory animals. Complete pathological facilities are available for examination of tissues and organs of test subjects. The Biochemistry and Physiology Branch predominantly investigates the mode of action of pesticides on a cellular and subcellular basis using laboratory animals. Epidemiological investigations on occupationally exposed workers are carried out in the Branch's Field Studies Section located at Wenatchee, Washington. Field investigations on the biological effects of pesticides and toxic substances are also carried out at Wenatchee. The Animal Resource Facility maintains the animal quarters for the entire ORD-RTP facility. Small laboratory animals, primates, and selected unusual experimental animals (e.g., voles) are maintained for use in pesticide and toxic substances research.

The basic purposes of these facilities are to maintain both a level of applied research in EPA's areas of responsibility and the means to respond to high priority problems. The maintenance of several fundamental areas of investigation allows the scientists to respond quickly to inquiries either through personal experience or by initiating programs to resolve the issues.

PHYSICAL FACILITIES

The physical facilities of the Pesticides and Toxic Substances Effects Laboratory, located both at RTP and in Wenatchee, are superior to most laboratories of comparable size and function. These facilities provide instruments for magnetic resonance studies using spectrophotometry, for atomic absorption studies, for mass analysis studies, and for combinations of chromatographic and mass spectroscopy techniques with integrated computer analysis for efficient, reliable analysis of pesticide residues. To maintain the sophisticated electronic instruments, a maintenance group provides repair and modification services to the Laboratory, to EPA pesticide contract laboratories, to other Federal and State facilities, to the World Health Organization, and to research laboratories of foreign governments. The PTSEL repository, containing approximately 450 standard reference pesticides, provides high-grade analytical standards for U.S. and foreign laboratories conducting a wide variety of studies. To support biological studies, radioactivity tracer equipment for measurement of low- and high-energy emitters is available. Complete facilities are available for the preparation and analysis of radioactive samples.

MAJOR PROGRAM AREAS

Health effects research on pesticides, toxic substances, and their residues includes: establishing the chemical identity of residues, with emphasis on significant conversion products; developing, improving, and validating residue measurement methodology; and conducting a biological research program aimed at evaluating the hazards of pesticides and their residues and conversion products by acquiring information on the effects of these materials on animals and (ultimately) on humans.

Pesticide Identification Methodology

The development of adequate methodology for the analysis of pesticides and their residues is a continuing problem requiring continual upgrading as new pesticides are introduced or usage patterns change. Multiple-residue techniques that will detect many pesticides simultaneously have simplified the regulatory analytical problems; but, they have also greatly complicated research and development programs. It is often difficult to fit a pesticide into a multiple-residue detection scheme without complicating the scheme with the pesticides for which it was originally developed. A large group of pesticides coming into increasing use is the anticholinesterase agents, that is, the carbamates and organophosphates. These agents are just now being fitted into such multi-residue techniques. Furthermore, multiple-residue detection techniques alone do not establish unequivocally the identity of the pesticide residue, particularly if artifacts or interferences are encountered. Identity of the residue must be confirmed by other methods, and a variety of such confirmatory methods must be available for the many different pesticides in use.

In addition to the adaptation of present methods to new chemicals and the development of new methods, improvements in the sensitivity, efficiency, rapidity, and simplicity of existing methods are needed to improve the effectiveness of a monitoring program. A quality control manual for pesticide monitoring is being developed to assure the proper analytical control of the use of pesticides. This analytical manual incorporates collaboratively tested methods for determining pesticides and other chemical residues in air, water, and food; in human and animal tissues; and in other environmental media. At the present time this manual has been prepared for a limited number of substrates and pesticide compounds; it is continually being upgraded. New and or improved analytical methods and detection systems for pesticides are being developed and published continually. Certain of these methods show promise regarding their suitability for analysis of substrates relating to humans and the environment and are being evaluated for inclusion into the analytical quality control manual.

Effects of pesticides and toxic substances are studied using laboratory animals.

In an effort to establish the identity of a residue in the presence of interfering materials, confirmatory methods such as mass spectrometry are being utilized. A high resolution mass spectroscopy laboratory has begun operation, and new methods for determining trace metals in human tissues and excreta that combine mass spectroscopy with other analytical tools including gas chromatography and atomic absorption have been developed. Through the application of gas-chromatography/mass-spectroscopy techniques, various pesticides have been identified in human tissues, including Mirex, Oxychlordane, HCB, Nonaclor, and other chlorinated pesticides and contaminants such as polychlorinated biphenyls.

Current methodology for determining pesticides in air is inadequate both for sampling and for identification purposes. Studies are currently in progress to correct this situation by amplifying the sampling phase of the methodology. A new trapping system for the further determination of pesticides in air samples has been laboratory tested and is being examined in the field.

Improved methodology for the determination of low-level organo-phosphate exposure in humans has been developed and is currently being field tested in occupationally exposed and normal populations. The urinary alkylphosphate method has been shown to be sensitive and reproducible for the determination of low-level exposure in humans and is expected to be a welcome addition to the analytical methodology currently available for defining such exposure.

Environmental samples (e.g., human tissues, wildlife, plants, and water) of dioxin contamination of range land and other areas from 2, 4, 5-T exposure have been analyzed to assure that this environmental contaminant has not been introduced to the U.S. through the normal use of herbicides.

In many cases, residue from the use of a pesticide comprises not only the chemical applied but also toxic degradation or other conversion products that may be formed on exposure to light and weathering. Metabolic products may be formed in animals and deposited in edible tissues or milk. This phase of the research program ensures that the composition of residues has been established and that the analytical methodology developed will measure all toxicologically significant residual chemicals. Metabolic studies of chlorinated pesticides have established the occurrence of a series of metabolites of the pesticide Lindane for which analytical methodology is currently being developed. The occurrence of these metabolites of Lindane, formed in the liver by the drug metabolizing system, forms the basis of an *in vitro* screening procedure for examining the biological effects of pesticides and other exogenous materials on drug metabolizing enzymes.

Test dose of pesticide is administered to pregnant rat using intubation technique.

Quality Assurance

A quality control program currently in operation includes: the calibration and upgrading of instrumentation, the standardization and distribution of materials for the determinative and clean-up steps in pesticide analyses, the distribution of standard reference material for use in quality control, and the evaluation of laboratory procedures and performances on standard reference materials. This program continually upgrades methodology and laboratory capability in the 15 U.S. laboratories involved in the study of health effects of pesticides. Each year, over 3000 analytical standards are shipped to approximately 420 laboratories around the world. All EPA laboratories routinely draw samples from a repository of standard reference materials for pesticide measurement that includes over 400 currently available analytical standards.

Quality control studies for clinical biochemistry and pesticide analytical determinations to assure reproductibility in data from various laboratories and various sections of the country give assurance that analytical methodology will be available to measure all toxicologically significant pesticides and that variations will be minimal.

The EPA Regional Office laboratories have recently become active participants in PTSEL's quality assurance program. Check samples consisting of spiked quantities of pesticide residue in blood and fat matrices were analyzed by the Regional Office laboratories in a study to determine the effectiveness of analytical methodology. In addition, a program of on-site laboratory evaluations is nearing completion. These projects have underlined the need to establish a pesticide-residue training program to upgrade EPA's analytical capability in residue analysis.

Health Effects of Pesticides and Toxic Substances

PTSEL's biological research program is directed toward evaluating the hazard of pesticide residues and their conversion products by acquiring information on the effects of these materials on animals and (ultimately) on humans. This applied research is directed to establishing the safety of pesticides and developing the scientific foundation for EPA pesticide policies. The research effort includes: development of data on new types of pesticides to facilitate EPA guidance of commercial work, more detailed examination of specific toxicological effects for their impact on safety evaluations, examination and development of new toxicological methods for evaluating product safety, and resolution of conflicting or equivocal data for a sounder evaluation of the safety of pesticides and their residues. With this information, environmentally safe pesticides can be registered, and safe tolerance levels and reliable enforcement policies can be established. In all cases, animal experimentation should produce measurable parameters that can be used for logical prediction of toxicity in humans. It is highly desirable to determine how toxic substances affect humans so that an animal species that will provide corresponding data useful in the safety interpretation can be obtained.

In brief, EPA's health effects research includes studies of the physiological and metabolic effects of pesticides in biological systems including: the metabolic fate of the compounds, and their biochemical reactions, the nature of the metabolic pathways and an evaluation of their effects in terms of toxic action, and the development of data on the direct effect of pesticides on humans. In this regard, previous primate studies on the effect of Carbaryl, a carbamate insecticide, have shown that the EEG is a sensitive tool for measuring biological effects. The effect of several pesticides on EEG parameters in squirrel monkeys was investigated and several points of interest emerged: the magnitude of alteration of the EEG did not correlate with the relative toxicity of the compound, similar EEG alterations were induced by chemically unrelated compounds, and carbaryl was effective in altering the EEG of squirrel monkeys at a dose that approximates the incidental or background exposure levels in humans. This low-level exposure to carbaryl was also responsible for certain changes in animal behavior. To correlate these effects and to determine if they can be duplicated in humans, portable EEG units were constructed and are being field tested in studies of people who are occupationally or incidentally exposed to pesticides.

Teratogenic effects of pesticides are studied through fetal necropsy.

The delayed neurotoxic demyelinating potential of several organophosphate pesticides was examined in animals. High concentrations of an experimental organophosphate insecticide were found to induce demyelination in the central and peripheral nervous systems causing irreversible paralysis in the animals. The significance of this unusual effect from a potentially commercial organophosphate pesticide is being further investigated to determine its significance to humans with regard to occupational exposure and ingestion of residues in food.

In a further effort to examine the physiological effect of pesticides, the impact of several chlorinated pesticides and contaminants on reproduction was examined in laboratory animals. Studies of the teratological significance of exposure to dieldrin, Mirex, photodieldrin, dioxin (several different isomers), and 2, 4, 5-T were evaluated. In addition, *in vivo* and *in vitro* screening techniques were developed for the evaluation of both the neurotoxicity and the biological effects of pesticides on liver function. These techniques have been useful in the screening of new pesticides prior to the initiation of long-term studies to evaluate their toxicological significance.

ALTERNATE PESTICIDES PROGRAM

The 1972 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended, places an increased emphasis on EPA to regulate pesticide chemicals through full consideration of the consequences on human health and on the environment from the use of pest control products. The determination to cancel or suspend a product registration is made after exhaustive review of the pesticide and of the potential harm of pesticide materials designated as potential substitutes. Recognizing the enormity of the program to evaluate the hazard of a pesticide and to assess the acceptability of a substitute if removal is indicated, a $5 million, 50-position program to study pesticides and feasible substitute chemicals was included as part of the proposed Agricultural, Environmental, and Consumer Protection Appropriation Bill for 1974.

Three integrated strategies were considered necessary to implement this program: (1) scientific review of known registered pesticides, (2) establishment of a cooperative liaison with industrial research and development to expedite the development of pesticides as substitutes for those removed from use, and (3) generation of data relative to the problem of a pesticides hazard as a function of toxicity, persistence, and potential for eliciting an undesirable response. The review processes will define data gaps in background information that can be filled by initiating research, monitoring, and testing programs.

PTSEL maintains several broad areas of responsibility, including inhalation toxicology; toxicity screening and testing; chemical determination of toxicologically significant impurities in commercial preparations of pesticides; and multiresidue methods for detection of pesticides. Primary programs are being designed to satisfy the questions arising in the review process of pesticides and to allow a rapid response to all inquiries and thus permit the review and administrative actions to be completed in a minimum of time. It is anticipated that this program will allow EPA to expeditiously remove materials from the market that are designated as harmful to humans or the environment, and will further allow EPA to rationally assess materials designated as substitute chemicals.

TOXIC SUBSTANCES EFFECTS PROGRAM

PTSEL has an expanding role in assessing the toxicity of synthetic organic compounds, metals, and metallic compounds and in developing sensitive analytical methods for measuring toxic substances in the environment. Currently, approximately two million chemical compounds are known; several thousand new compounds are synthesized annually. Each year, several hundred of these new chemicals are introduced into commercial use even though their potential impact on health and the environment in most cases is not known.

The pending Toxic Substances Control Act (TSCA) is an important legislative approach to control the introduction of toxic substances into the environment. Rather than focusing on pollutants in the media (e.g., air and water), the TSCA relies on understanding the flow of potentially toxic substances throughout the entire range of activity – from extraction (or synthesis), through production and consumer use, to disposal. Of particular concern are the potentially deleterious effects on health resulting from long-term exposures to low levels of these chemicals, alone or in combination.

PTSEL projects over the past year have supported the research needs of EPA's Office of Toxic Substances. Animal model studies were completed on the effects of polychlorinated biphenyl compounds, hexachlorobenzene, cadmium, and TCDD (2, 3, 7, 8-tetrachlorodibenzo-p-dioxin). Preparing for public hearings, PTSEL carried out over 300 ultra-trace (ppb) determinations of TCDD in a variety of environmental samples (including human adipose tissue and agricultural products) utilizing an improved sample-preparation procedure followed by high-resolution mass-spectrometry analysis.

Future research on toxic substances will include development of rapid toxicological screening methods; determination of toxic impurities in commercial chemicals; development of a tissue bank to assess the accumulation of toxic substances in human tissue over long time periods; and the development of chemical analytical methods for the determination of trace levels of metals, metallic compounds, and synthetic organic compounds. PTSEL is also planning to develop a rapid-response capability to address environmental crisis situations that will involve short-term sample collection, chemical analysis, and toxicological assessment.

Extramural Program

The extramural research grant and contract program authorized in part by FIFRA and in part by the Public Health Service Act continues to support extramural pesticide activity through grant and contract research funds. The following program titles indicate areas of extramural study that provide data to augment PTSEL's research supporting the regulatory activity of EPA:

Pesticide-caused malformations in rat fetus are often revealed through tissue magnification.

Mode of Action of Cyclodiene Insecticides – University of Arizona

Metabolic Interations of Hormonal Steroids and Chlorinate Hydrocarbons – University of Michigan

Mechanisms of Pesticide Degradation – University of Wisconsin

Actions of Pesticides and Other Drugs on Male Reproductive Organs – West Virginia University Medical Center

Chemistry and Mode of Action of Insecticides – University of California (Riverside)

Biological Hazards of Phototransformed Pesticides – Stanford Research Institute

Metabolism of Carbamate Insecticides – University of Kentucky

Mixed Function Oxidases in Insecticide Action – University of Illinois

Pesticide Epidemiological Field Studies – University of Miami

N.M.R. Studies on the Molecular Interactions of Pesticides of Environmental Concern – Oregon State University

Investigation of Pesticides in Human Milk – Meharry Medical College

Sensitive Specific Fluorescence Immunoassay Methods for Detecting Organic Contaminants – IntelCom-RadTech

Intermolecular Interactions Between Environmental Toxic Substances – Florida State University

Development of *in vitro* Screening Methods for Evaluating the Neurotoxic Potential of Pesticides and Toxic Substances – Duke University Medical Center

Optimization and Evaluation of a Microelectrolytic Conductivity Detector for Gas Chromatographic Determination of Pesticide Residues – Purdue University

Identification of Toxic Impurities in Technical Grades of Pesticides Designated as Substitute Chemicals – Battelle Memorial Institute

Extension of Multi-residue Methodology – University of Florida

Toxicological Evaluation of Materials Found as Impurities in Technical Preparations of Pesticides Designated as Substitute Chemicals – Battelle Memorial Institute

Inhalation Toxicological Studies of Chemical Pesticides Designated as Alternate or Substitute Chemicals – Stanford Research Institute

Organophosphate Insecticides on Benzo(a)Pyrene Carcinogenesis – Thomas Jefferson University

Development and Standardization of Identification and Monitoring Techniques for Baculovirus Pesticides – University of Texas

Toxaphene Composition and Toxicology – University of California

Metabolism and Toxic Effects of Dithiocarbamate Fungicides in the Rat – Vanderbilt University School of Medicine

Toxicity, Interactions, and Metabolism of Import Pesticides in Mammals – Purdue University

Development of Isolated Embryo Screening Techniques to Assess Early Effects of Trace Metals and Synthetic Organics on Mammalian Embryogeneses – North Carolina State University

Screening Method for Toxic Substances – Syracuse University Research Corporation

Electroencephalogram changes have occurred in laboratory monkeys after long-term, low-level exposure to some pesticides.

LEGISLATIVE MANDATE

Public law and policy and the traditions of many decades have directed governmental efforts to assure that the nation's food supply is safe, clean, and wholesome. EPA, committed to full enforcement of these laws, has developed criteria and protocols for pesticides and toxic substances that are effective, workable, and enforceable. The wholesomeness of any food supply depends in part on the quality of the total environment: the soil, water, and air in which the food is grown, processed, and consumed. Contamination of these basic natural resources by pesticide residues and other pollutants can affect not only the safety of food products but also other environmental values such as water quality, wildlife preservation, and outdoor recreation. EPA is actively seeking to protect and manage these resources in the interest of greater human safety and welfare.

The statutory authority for the regulation of pesticides and pesticide residues delegates the responsibility for the registration of pest control materials to EPA. In addition, the establishment of tolerances for pesticides in or on human food and feed for animals has been delegated in part to EPA and in part to the Food and Drug Administration of the Department of Health, Education, and Welfare.

If the proposed use of a pesticide will result in residues on a food or feed crop, a registration for its use is granted provided a tolerance has been established by the regulatory authorities within EPA. The regulation of pesticide and pesticide residues by the Federal government encompasses those pesticides or residues involved in interstate commerce. Pesticides in food supplies produced and used within a State are under the jurisdiction of that State. The various Federal agencies work closely with their State counterparts in pesticide regulation and control, however.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), enacted in 1947, regulates the marketing of economic poisons and devices. This act was amended in 1959, 1964, and more recently in 1972 to include the Federal Environmental Pest Controls Act (FEPCA).

The term "economic poison" is defined as any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating forms of plant and animal life (such as insects, rodents, fungi, and weeds) or viruses (except viruses on or in living humans or other animals) and any substance or mixture of substances intended for use as a plant regulator, defoliant, or dessicant. Under this act no pesticide chemical may be legally shipped in interstate commerce for general use until it is known to be safe when used as directed and effective for the purpose claimed on the label. Also, any residues that may remain in or on feed or food must not exceed the safe tolerance levels established under the Food, Drug, and Cosmetic Act (FDCA). FIFRA prohibits the shipment in interstate commerce of products that are not registered or are adulterated or misbranded. Products that are in violation of the Act may be seized and criminal action instituted against the shipper of such products. In the more recent amendment (FEPCA), in addition to directing labeling restrictions for pesticide registration, EPA is responsible for: prescribing standards for the certification of applicators of pesticides; administering the use permits system; registering pesticide producers including the examination of records and books and the inspection of plants; conducting research and monitoring activities including monitoring air, water, soil, humans, plants, and animals; and regulating pesticides imported to or exported from the country.

EPA's authority for the establishment of tolerances for pesticides in or on foodstuffs or raw agricultural products is provided by the Pesticide Chemical Amendment (PCA) of the FDCA. The paramount purpose of this Act is to assure the safety of the nation's food supply. In part, this assurance is provided by ensuring that the residues remaining on the food are safe for consumption and by requiring government clearance before a pesticide is used. This Act further provides for seizure and destruction of agricultural commodities that contain pesticide residues in excess of established tolerances. Where no tolerance has been established, commodities carrying residues in excess of established working levels are also subject to seizure and destruction. This Act also provides both for criminal penalties for violation and for legal injunctions to halt use. The FDCA outlines the data and information to be furnished and the procedures to be followed for obtaining a pesticide tolerance. Additional procedures and more specific data requirements in the regulations ensure that food safety requirements are met prior to establishing a tolerance. As provided under Section 408 of the FDCA, tolerances are established for raw agricultural commodities, not for processed food. If the residues remaining in a processed food have been removed to the fullest extent possible through good manufacturing processes and do not exceed the tolerances on the raw product, the processed product complies with the law. In general, the residues in processed food are a fraction of the amount permitted on the raw agricultural product. To cover the residues of pesticides applied to or concentrated in processed foods, tolerances may be established under Section 409 of the Food Additives Amendment of the FDCA, administered by the Food and Drug Administration. Because the major use of pesticides in the U.S. is on raw agricultural commodities, the overwhelming majority of established tolerances are on these products. Ideally pesticide residue tolerances should apply to ready to eat food on the dinner plate because it is the quantity of pesticide actually consumed that has health significance; however, tolerances established at this point in the food chain would not be practical. Therefore, a point in the distribution system where meaningful, corrective action can be taken to prevent the consumption of unsafe amounts of pesticide chemicals has been selected. The tolerance concept does not anticipate, as a practical matter, that all foods will contain residues of all chemicals as high as the established tolerance level, or even that all of a single food will always contain a residue at the tolerance level.

Within the framework of registration of pesticides and of establishment of a tolerance for pesticides, several considerations must be advanced: the registered use and the tolerance level must be safe for the applicator, the consumer, and the environment; the level of residue must be safe if all of a particular raw food containing residues at the tolerance level is always consumed; the tolerance will not reflect the average residue on a commodity but will represent the maximum residue that will remain under good agricultural practice; the tolerance generally is established on raw agricultural commodities and does not realistically reflect the residue in or on food as eaten; and the tolerance will be set only at levels reasonably required to cover the residue likely to occur as a result of good agricultural practice. In the regulation of pesticides, EPA's policy is to minimize the exposure of the consumer and the environment to pesticides and their residues in the interest of safety and reduced environmental contamination.

To register a pesticide and to establish tolerances for the pesticide in or on raw agricultural commodities, toxicity tests on the proposed material must be conducted to show that the directed use of the product would not be injurious to humans, other animals, or the ecological system when warnings and cautions are carefully heeded. The extent of toxicological data required to fulfill these requirements varies with the nature and proposed use of the product. Biological tests under field and laboratory conditions must be conducted to determine if the product will control the pests named on the label when used as directed without causing a significant adverse effect to the crop or the property being treated. The basic requirement for registering pesticide chemicals and establishing tolerances is that the data and other information, when evaluated as a whole, will establish the safety of the proposed pesticide usage. This judgment is made by personnel qualified by training and experience to evaluate the safety of pesticide residues in or on food. In addition to toxicological requirements, suitable methods of analysis must be available for monitoring and enforcing the proposed registration. Sensitivity, accuracy, and precision in available analytical methods must be evaluated in relation to the proposed use and toxicity of the pesticide chemical. Extraction and clean-up procedures must efficiently remove and recover residues from treated samples from suspected cases of contamination.

Data requirements for registration and for the establishment of tolerances are subject to continual review in light of new scientific data and information. Specifically, advances in scientific knowledge are continually evaluated to provide the necessary criteria for the conclusions made concerning the safety of pesticides.

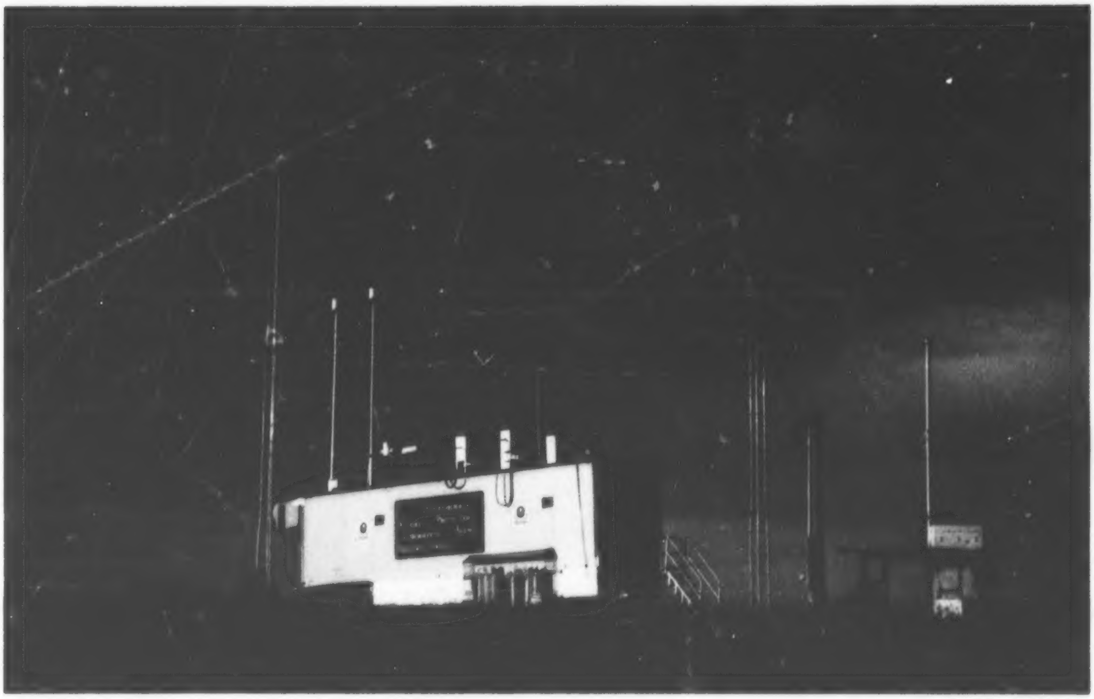
Table 12 is a summary of the resources employed by PTSEL for Fiscal Year 1974 under the Federal Environmental Pesticide Control Act of 1972, Section 20.

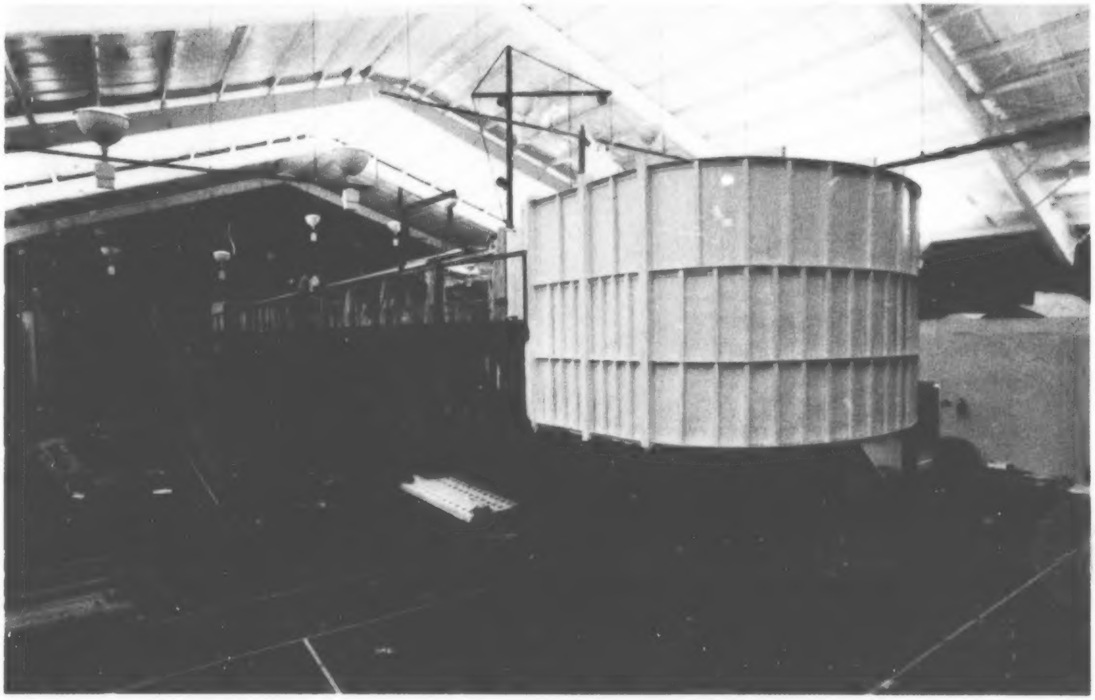
Table 12. SUMMARY OF RESOURCES FOR PESTICIDES AND TOXIC SUBSTANCES EFFECTS LABORATORY FOR FISCAL YEAR 1975

(Federal Insecticide, Fungicide, and Rodenticide Act, As Amended)

Category	Funds, $\$10^3$
Pesticides health effects research	2,252
Pesticide identification methodology	504
Toxic substances health effects research	620
Quality assurance	327
Alternate pesticides program	1,595
Total	5,298

Environmental
Sciences
Research
Laboratory





Chemistry and Physics Laboratory

OVERVIEW OF CPL MISSION

Chemistry and Physics Laboratory (CPL) manages and conducts an intramural and extramural research program that provides (1) techniques and instrumentation for the measurement of atmospheric pollutants, (2) information on the chemical and physical transformations that pollutants undergo in the atmosphere, and (3) information on the effects of atmospheric pollutants on materials. While each of these program areas contributes directly to the air pollution control program, all are also closely interrelated: air pollution measurement techniques and instrumentation research support atmospheric chemistry and physics studies; atmospheric chemistry and physics studies provide information on what measurement techniques are needed; and studies of the effects of atmospheric pollutants on materials provide information on mechanisms whereby pollutants can be removed from the atmosphere.

ORGANIZATION

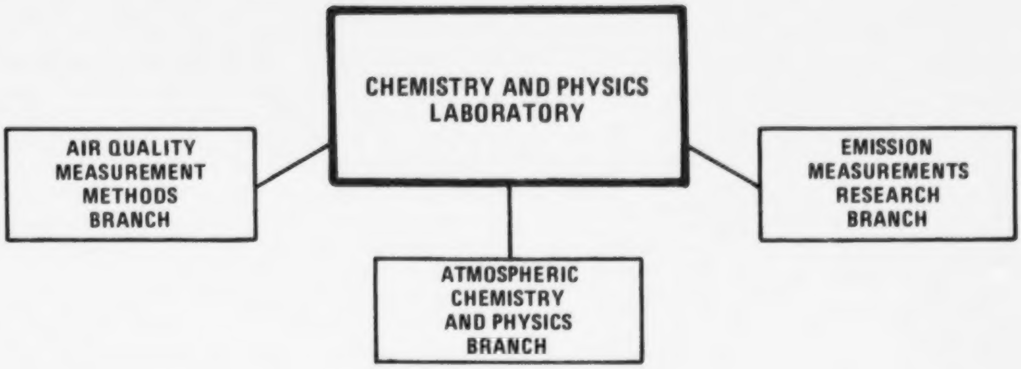
The Chemistry and Physics Laboratory is organized into three branches. One of these deals with the problems of the physical and chemical transformations of pollutants in the atmosphere, and the other two are concerned with the development of techniques and instrumentation for the measurement of air pollution. All three branches are involved in both laboratory and field research and implement their programs through in-house projects and extramural research grants, contracts, and interagency agreements.

Atmospheric Chemistry and Physics Branch

The program of the Atmospheric Chemistry and Physics Branch involves both laboratory and field studies. Laboratory studies are conducted in clean glass chambers with synthetic mixtures and in large irradiation chambers with real mixtures such as motor vehicle exhaust. Hypotheses developed in these laboratory studies are tested in the field by analysis of the atmosphere at critical sites chosen on the basis of the pollution sources, meteorology, and topography of the area.

The results of the measurements are expressed in mathematical models of the atmospheric chemical transformations. The laboratory and field studies are

EPA research groups use a mobile laboratory for aerosol studies and a water channel-towing tank for fluid modeling studies.


CHEMISTRY AND PHYSICS LABORATORY
AIR QUALITY MEASUREMENT METHODS BRANCH
EMISSION MEASUREMENTS RESEARCH BRANCH
ATMOSPHERIC CHEMISTRY AND PHYSICS BRANCH

centered on the following principal atmospheric problems: (1) transformation and removal of oxides of nitrogen and organic compounds, (2) oxidation and removal of sulfur dioxide, (3) relationships between oxidant and its chemical precursors, (4) the characteristics and origins of atmospheric aerosols, (5) visibility reduction by atmospheric pollutants, (6) interactions between pollutants and surfaces; and (7) distribution and reactions of halogenated pollutants. The scientific data obtained in these studies provide a basis for decisions on air pollution control actions.

Air Quality Measurement Methods Branch

The Air Quality Measurement Methods Branch conducts research operations providing EPA with the capability of assessing environmental quality. This research is designed to produce and evaluate new and improved techniques for the identification and quantification of contaminants in the environment for field and laboratory use. The Branch develops instruments for performing continuous or periodic monitoring of the environment with minimal human attendance, and develops sensor systems for air quality measurement of pollutants in ambient air. Staff personnel provide methods for the analytical extraction of contaminants from the environment and for the qualitative and quantitative analysis of said contaminants after transport to the laboratory.

Emission Measurement Research Branch

The Emission Measurements Research Branch conducts research and development activities to provide analytical techniques and instruments for the identification and precise measurement of environmental pollutants in emissions discharged from all types of sources, both mobile and stationary. These activities are carried out primarily to support the implementation of national emission standards for mobile sources, performance standards for new stationary sources, and national emission standards for hazardous air pollutants as required under the provisions of the Clean Air Act of 1970. This Branch also conducts studies for the chemical and physical characterization of pollutants emitted from various sources.

PHYSICAL FACILITIES

A long-path infrared spectroscopy system capable of a 1 kilometer path length is operated by EPA personnel. The long-path cell is also an irradiation chamber with a basic length of 30 feet. The use of a Fourier Transform spectrometer and a computer for immediate data analysis permits detection of pollutants at concentrations of a part per billion (by volume). The system is now used to detect pollutants that have not been measured or that have been measured only with difficulty both in the laboratory and in the field.

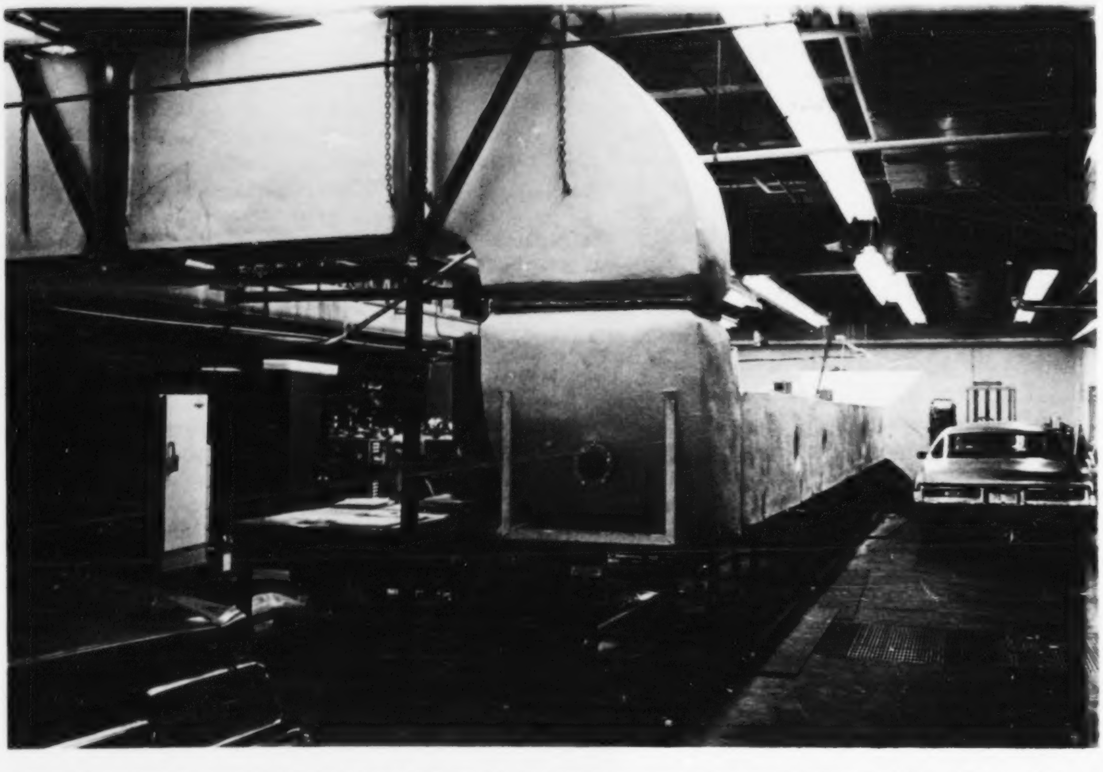
Several mobile laboratories are used for field studies of atmospheric chemistry and physics. These laboratories are equipped with gas chromatographs, ozone, sulfur dioxide, and nitrogen oxides analyzers. Aerosol sampling and sizing equipment is available, as well as weather monitoring equipment.

Two smog chambers are operational for simulation of polluted atmosphere for study of aerosol formation and growth and hydrocarbon/nitrogen-oxide/oxidant reactions. A high-altitude chamber is being built for the study of ozone-Freon interactions.

A research prototype lidar system, designed specifically for particulate emission measurements from stationary sources, is housed in a mobile van to facilitate field studies now in progress. This system provides a capability for measurement of the opacity of particulate emissions at ranges of 0.5 to 1 kilometer from pollution sources.

For the remote optical sensing of gaseous emissions from stationary sources, a research infrared spectrophotometer (ROSE System) is available. This instrument is also capable of long-path measurement of extended source emissions. The ROSE System has scanning capability in the 3- to 5- and 7- to 14-micron wavelength range and high resolution (1.0 cm^{-1}). It is housed in a mobile van and used to support field studies that characterize gaseous emissions from various source industries.

An experimental stationary source simulator is installed in a leased facility at the Beaunit Corporation Technical Center in the Research Triangle Park. This facility is used to generate test flue gases with particulate matter, moisture, and other pollutants under defined conditions that must be known so that sampling and analysis methods can be evaluated under controlled experimental situations before actual field testing is undertaken. This equipment provides a 0.6 x 0.9 x 10.5 m (2- by 3- by 35- foot) test section, up to 233°C (450°F) flue gas temperature, and 24 m/sec (80 ft/sec) flow velocities to simulate conditions encountered in typical power plant operations. Extractive and cross-stack optical



Pollutant emission patterns from exhaust stacks of stationary sources are simulated using ORD-RTP's wind tunnel. Test automobiles are used in developing measurement methods for mobile sources.

instruments, as well as remote sensing systems, are tested at this facility before actual installation or field testing at various industrial sources.

An X-ray fluorescence multispectrometer system is now available for rapid elemental analysis of airborne particulate samples. By automated operation of an array of crystal spectrometers, the system achieves high resolution, sensitivity, and speed in analyzing large numbers of samples for up to several dozen elements.

The electron optical facilities include scanning electron microscopy (SEM), transmission electron microscopy (TEM), and X-ray diffraction equipment. The SEM, used for morphological studies of stationary and mobile source particulate emissions, is equipped with two X-ray spectrometers that give it a capability for quantitative and qualitative chemical analysis as well. The wavelength X-ray spectrometer allows conversion of the SEM to an electron microprobe for quantitative chemical analysis of particles smaller than 1 micron in diameter. The energy dispersive X-ray spectrometer allows qualitative chemical analysis, for elements beyond sodium, of particles only a few hundred angstroms in diameter. The TEM is used for examination of particles smaller than 0.1 micron diameter where crystal structure is an important consideration. Electron diffraction techniques afford a means of identifying the compound species of the particles being examined. X-ray diffraction is used for identification of crystalline material or mixtures. Quantitative analysis is possible from observation of intensities of X-ray maxima as a function of percentage composition of a crystalline phase.

The Laboratory's capability for research on mobile source emission measurements includes instruments for analysis of particulate and gaseous components such as sulfates, fuel-additive components, and other nonregulated emissions. This general capability is provided by analytical facilities that include:

1. Hitachi RMU-6L mass spectrometer coupled to a Perkin-Elmer 990 gas chromatograph. The mass spectrometer accurately measures the atomic mass of molecules presented to it, while the gas chromatograph provides fractionation by the principle of absorption. The mass spectrometer can also analyze gaseous and liquid samples to provide unique information on the molecular weights of the chemical species present.
2. Gas chromatography capability for separating and analyzing automotive exhaust by its individual components. This capability typically results in identifying over 100 hydrocarbons and many substituted organic components, and is being expanded to higher molecular weight components. The principles involve selective absorption, elution, and detection using flame ionization detectors that respond with extreme sensitivity to individual carbon atoms. Typical sensitivities are about 0.01 ppm. Special techniques allow these limits to be extended approximately an order of magnitude.
3. Other general analytical equipment include Nuclear Magnetic Resonator atomic absorption, (Varian T60), infrared spectrophotometer (P-E 180), Ultra-violet-visible spectrophotometers (Cary Model 14 and Beckman Model B), chemiluminescence equipment, microbalances, liquid chromatographs, and other modern analytical laboratory instruments.

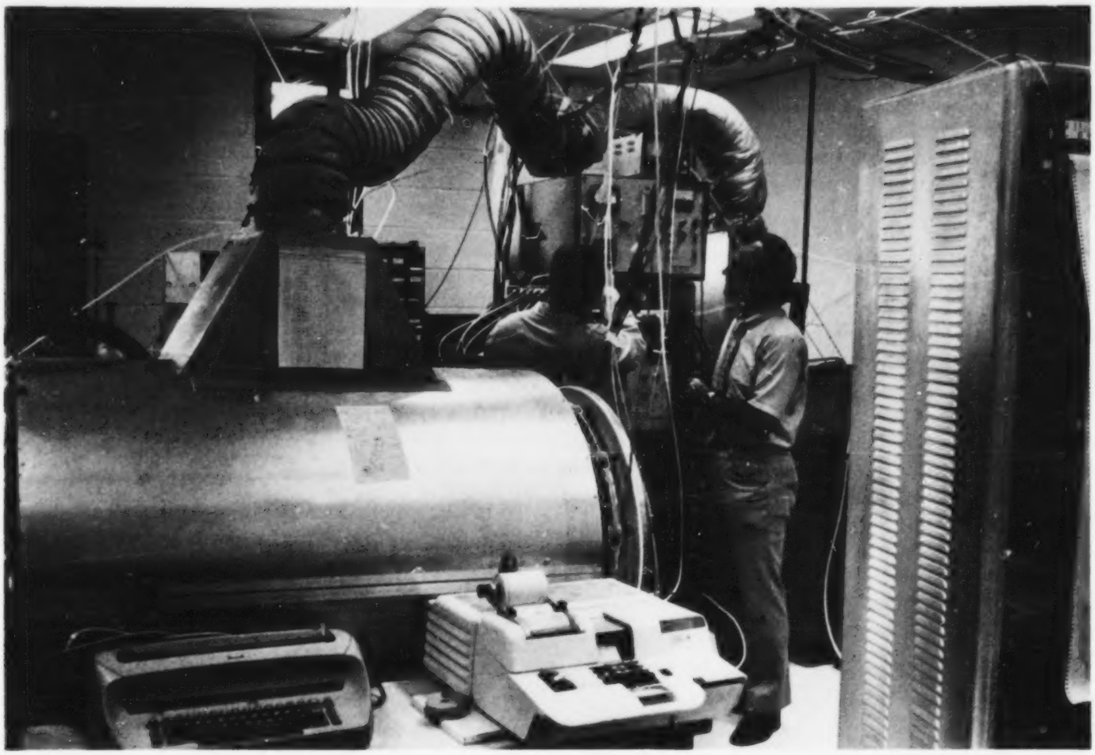
The mobile source testing facility is located partially in the Environmental Research Center facility and partially in leased space in the Beaunit Technical Center in RTP. The facilities consist of test stand arrangements for evaluating new emission measurement methods, for studies of fuel and control systems effects on automobile and truck tailpipe emissions, and for work on evaporative emissions.

Two chassis dynamometers are available for testing passenger cars and light trucks weighing up to 4.5 tennes (10,000 pounds). These treadmill-like devices simulate the roadway loading effects on a stationary automobile, including such factors as the influence of car inertia on accelerations and decelerations, tire friction, and aerodynamic drag. With this apparatus, it is possible to operate a car over controlled driving cycles to derive a close approximation of vehicular emission characteristics for city street, urban expressway, or highway cruising models. Such equipment is also useful for the measurement of fuel consumption over standardized representative driving routes.

Chassis dynamometers such as these are useful in development of analytical methods and instruments for measurement of pollutant substances in certifying motor vehicles and for studies of pollutant emission patterns for both production and prototype cars.

Three engine dynamometer test stands are also available to simulate road influence on engines removed from cars and for studies of control system performance. Tests on these dynamometer stands are inherently more controllable than are whole-vehicle tests. Such equipment is particularly useful for studies of fuel composition and additive effects where subtle changes must be detected; for automated, rapid mileage accumulation; and particularly for studies of the influence of engine operating parameters on pollutant emissions.

Two of these engine dynamometer stands are capable of simulating gasoline engine and control system operation over a wide variety of cyclic and steady-state conditions. The third stand has a similar capability with medium-and heavy-duty diesel engines up to 375 horsepower.



Atmospheric photochemical reactions of pollutants are studied in ORD-RTP's small "smog chamber."

All five test stands are equipped with appropriate particulate and gaseous emission sampling devices. The gasoline engine stands mount EPA-designed dilution tunnel samplers together with constant variance-type gas samplers. The diesel engine dynamometer uses a special particulate-gas sampler (developed for CPL under contract) that permits operation over the 13-mode Federal test cycle.

The test stands are also equipped with a variety of state-of-the-art analytical instruments suitable for both continuous and grab-sample measurements of gaseous emissions.

MAJOR PROGRAM AREAS

Principal efforts of personnel of the Chemistry and Physics Laboratory are aimed at: (1) studies of the physical and chemical transformations that pollutants undergo from source to receptor in the atmosphere, (2) development of techniques and instrumentation for measuring ambient air pollution, and (3) development of techniques and instruments for measuring pollutants in emissions from sources.

Pollutant Transformation

Formation and Removal of Noxious Gases in Atmosphere—Transformations of sulfur oxides, nitrogen oxides, and organic pollutants are being identified and described quantitatively. Both gas and condensed-phase processes are under investigation. Reactivities and reaction paths are being established. Intermediate chemical species as well as final oxidation products are being identified and measured. Real atmospheres are studied with mobile equipment at selected locations. Simulated polluted atmospheres are studied under controlled conditions in the laboratory. Results, applied to the mechanisms of chemical reactions, are yielding parameters for the mathematical modeling of the atmospheric transformation processes. The results are disseminated in reports on the chemical and physical processes involved in the formation, transport, and removal of toxic and noxious substances in the atmosphere: insights into the self-cleansing properties of the atmosphere, are given, rate and mechanism data are provided for the mathematical modeling of the reactions in the polluted air, relationships between pollutant emissions and adverse effects are described, and advice is given as to control strategies for minimizing the formation of noxious gases in the atmosphere.

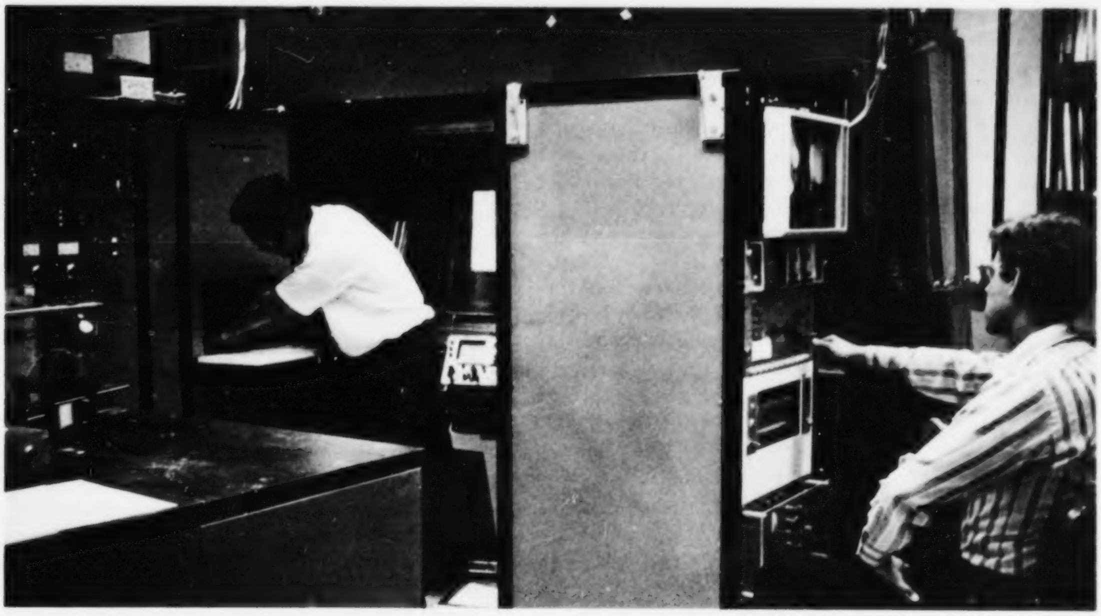
Halogenated Compounds in Atmosphere—Research programs on halogenated pollutants have been underway in CPL for several years. Recent findings on ozone-Freon interactions in the stratosphere have given a new urgency to these studies. CPL research activities on halogenated compounds include measuring ambient levels in the field and carrying out laboratory studies of photochemical reactions and reactivities under smog type conditions, determining diffusion rates, and identifying removal processes. Recent research has shown the ways in which vinyl chloride, 1, 1 dichloroethylene, trichloroethylene, and tetrachloroethylene react under moderate smog conditions. Further data are being sought on the sources, sinks, and chemical effects of the many types of halogenated air pollutants.

Oxidant Transport to Nonurban Areas—Previous studies in California have suggested that high ozone levels observed in nonurban areas are a result of the transport of oxidants and oxidant precursors from large urban areas such as Los Angeles. More recently, high ozone levels have been studied in nonurban areas of West Virginia, Ohio, Florida, and New York. In each case, the data suggested that high ozone levels are due to the long-range transport of ozone and/or ozone precursors. Additional field studies will be carried out in the New England area. A thorough analysis of all the data gathered may indicate that control strategies must be designed for entire regions.

Determination of Oxidant/Precursor Relationships for Control Strategies—Oxidants are legally controlled pollutants, but they are not emitted directly into the atmosphere. Oxidants are formed in the air by photochemical reactions involving nitrogen oxides, oxygen, and hydrocarbons. The word oxidant designates material that causes an oxidation reaction in certain test procedures. Oxidants generally consist of about 90 percent ozone and 10 percent peroxyacetyl nitrates.

Control of oxidants follows from control of their precursors, nitrogen oxides and hydrocarbons. Permissible limits of precursor concentrations must, therefore, be based on knowledge of photochemical processes in the air.

Both laboratory and field studies are being conducted to determine oxidant/precursor relationships. Current laboratory studies are concerned with oxidant/precursor dependencies under conditions simulating (1) above-city atmospheres, (2) wind-trans-



Elemental analyses of atmospheric aerosols are conducted using X-ray fluorescence techniques.

ported urban plumes, (3) nonurban atmospheres, and (4) future atmospheres as modified by ongoing emission control. Field studies concern the potential formation of oxidants from natural organic emissions. Emission analysis and inventory studies are also being conducted to explore the utility of a selective emission control concept in oxidant abatement strategies.

Character and Origin of Aerosols—Physical and chemical properties of source, ambient, and natural aerosols are being determined. The major sinks for aerosol pollutants are being identified and the removal rates are being defined. The effects of the aerosols on gas-phase atmospheric chemical reactions are under investigation, along with the gas/particle conversions and the particle-removal processes. The results of the research are being used to establish the contribution of the various sources to the ambient atmospheric aerosol loading; characterize urban, natural, primary source, and secondary source aerosols; develop quantitative descriptions of generation and removal rates associated with each major aerosol source and sink; and quantify aerosol effects on atmospheric chemical reactions. The scientific data are basic to the promulgation of fine-particle criteria and standards and to the development of effective control procedures.

Relating Fine-particle Aerosols to Sources—The pollution aerosol is a dynamic system whose physical and chemical characteristics depend in a complex way on the background aerosol and on particle and gas emissions. The goal of this research is to develop experimental and theoretical methods for relating the properties of the pollution aerosol to the characteristics of emission sources. This is being accomplished by (1) beginning with the observed characteristics of the pollution aerosol and formulating a set of hypotheses relating the aerosol to the sources of particles and gases, (2) carrying out laboratory experiments and theoretical calculations aimed at testing these mechanisms, and (3) arriving at a tested quantitative understanding of the origins of the smog aerosol. Experimental studies include investigations of the conversion of organic gases and sulfur dioxide to particulate matter in an ozone-rich atmosphere.

Regional Air Pollution Study: Air Quality Characterization—The monitoring network of the RAPS will measure gaseous pollutant concentrations and meteorological variables for use in modeling the transport of the pollutants in the urban air mass. The network will have little impact on describing and modeling the transformations of the pollutants, however, especially aerosol formation and growth. It has therefore been necessary to establish this subprogram, which addresses atmospheric chemistry problems.

Atmospheric particulate matter is analyzed using liquid chromatography.

A team of experienced aerosol scientists was assembled in St. Louis in the summers of 1973 and 1974 to conduct an intensive aerosol characterization program. Previous experience with the California aerosol study was the basis for the development of this aerosol study. Special EPA mobile facilities were used for aerosol characterization. The results of the study are currently being analyzed and developed for publication. Two gaseous pollutant transformation projects have been undertaken: the first is the study of the transformations of nitorgen oxides and sulfur oxides in power plant plumes; the second is laboratory verification of the kinetic models that are to be applied to the network data.

The program output includes: identification of sources of visibility loss in St. Louis; specifications of particle sizes, spectra, and chemical composition; fine-particle spatial distribution; identification of gas/particle interactions for development of visibility reduction models; data on choice of tracer substances for study of regional atmospheres; and chemical inputs to the photochemical modeling effort.

Effects of Air Pollutants on Materials—The damaging effects of air pollution on a wide variety of materials have been recognized for many years. Both laboratory and field studies have shown that polluted environments can (1) accelerate the corrosion rates of many metals; (2) produce fading in certain economically important textile dyes; (3) cause products made from common types of rubber to crack; (4) reduce the service life of oil-base house paints; (5) deteriorate a number of building materials such as limestone, marble, and mortar; (6) discolor and physically damage statuary and other works of art; (7) degrade certain textile fibers, especially cotton and nylon; (8) embrittle and discolor paper; and (9) weaken leather. Although these cause-effect relationships are well-known, the important need today is comprehensive information on dose-response relationships. Such information is needed to set secondary air quality standards and to make cost-benefit studies.

As a first step in fulfilling this need, CPL researchers planned, conducted, and recently completed, a statistically designed laboratory exposure study to establish cause-effect relationships between pollutants (SO_2, NO_2, and O_3) and economically important materials. Five controlled-environment exposure chambers especially designed for this study were used. The results showed that weathering steel, galvanized steel, stressed high-strength aluminum alloy, marble, and oil-base house paint were mainly affected by airborne sulfur dioxide and relative humidity, and the interaction between the two. When the magnitude of damage and the economics of materials selection and replacement were considered, vinyl and acrylic coil coatings, vinyl plastic siding, and white tire-sidewall rubber were not appreciably affected by any of the pollutants. The results of this study will be published as a special EPA report.

Ambient Pollutant Measurement

Ambient Air Particulate Measurement—This project provides EPA with the ability to measure parameters known or judged relevant to pollution of the atmosphere by suspended particles. Parameters presently considered include mass, particle size distribution, and elemental composition.

Noteworthy progress has been made in designing devices capable of collecting particles in regimes of two sizes (0 to 3.5 and 3.5 to 20 micrometers). Samples are examined for mass determination by beta-ray attenuation, and for elemental composition by X-ray fluorescence. Filters, filter holders, filter transport mechanisms, and identification coding and decoding devices have been designed for total compatibility, resulting in a system geared to the handling of large numbers of samples with minimum opportunity for human error.

A major accomplishment has been the development of a simple, sensitive, and reasonably specific device for the automated collection and quantification of sulfuric acid mist. Evaluation is now in progress.

Important progress was made toward development of a rapid, sensitive, and precise method for the measurement of benzo(a) pyrene, an important carcinogenic pollutant.

Future efforts will include further improvements in collection, sizing, and analyzing techniques, and development of objective methods for assessing visibility reduction.

Fine-particulate Methodology—This program will provide a simple, low-cost device that will effect the dichotomous collection of respirable and non-respirable particles from ambient air in a manner compatible with subsequent assessment of their mass and chemical composition.

On-the-scene research into atmospheric aerosol behavior is performed using ORD-RTP's mobile laboratory.

A contract for prototype two-stage collection devices that will be fieldworthy yet amenable to production at moderate cost was completed in 1975. Design criteria included an intake section whose performances will not be seriously affected by wind direction or speeds of up to 15 km/hr.

Future activity will include field evaluation of the product described above and fabrication of improved second-generation prototypes. Every effort will be made to provide the capability of real-time assessment of atmospheric fine-particle burden in the final product. A corollary activity is the development of reliable methods for generating monodisperse aerosols of precisely known particle size for use in the calibration of sizing instrumentation.

RAPS Measurements and Instrumentation—This program provides measurement capabilities necessary to complete the Regional Air Pollution Study. RAPS has its own X-ray Fluorescence Analyzer capable of analyzing collected particulate samples for up to 30 elements. Sensitivity and analysis time are sufficient to handle large numbers of samples collected over periods of 2 hours or more.

Twelve automated dichotomous samplers were fabricated to collect particulate samples and segregate respirable from nonrespirable fractions. These samplers have been installed in St. Louis and are currently fully operational. A beta-gauge was developed to assess the mass of particles in each fraction collected. This gauge will be fabricated to handle the same samples collected for X-ray analysis.

Two separate laser-powered, long-path spectrophotometers were developed for use in RAPS for determining gaseous pollutant burdens, averaged over line-of-sight paths of up to 1 kilometer. Results will be utilized in improving pollution-transport modeling capability. These instruments are capable of analyzing carbon monoxide, ozone, and sulfur dioxide, and other pollutants.

EPA personnel, working with researchers from the Lincoln Laboratory and the General Electric Company, performed the first field experiments employing long-path monitors. Ambient carbon monoxide and ozone have been measured at selected sites in the Regional Monitoring System in St. Louis. The unique ability of path monitors to measure average concentrations over long linear distances provides validity checks of on-site measurements.

A gas-chromatographic instrument capable of measuring acetylene at levels of 0.1 ppb was fabricated under contract. This capability will be used in studies using accetylene as an intrinsic tracer substance indicative of automotive traffic.

Further work in this program will consist largely of field trials and applications of the techniques described above.

Instruments for Measuring Gaseous Pollutants in Ambient Air—This program provides EPA with both instrumental and laboratory methods for the measurement of important gaseous pollutants such as ozone, nitrogen oxides, sulfur oxides, carbon monoxide, and hydrocarbons. Its aims are: to provide measurement capability for a specific pollutant where a need is known to exist, to improve that capability to an EPA-acceptable level of reliability, to simplify the hardware resulting from initial efforts to a degree permitting routine operation of the method or instrument by personnel available to enforcement agencies, and to seek design optima (or alternate methods/instruments) that will facilitate proliferation at costs commensurate with available resources.

A simple, sensitive monitor for vinyl chloride was developed through in-house research. Specificity and sensitivity of response are achieved by gas chromatographic separation followed by detection of the chemiluminescence from the gas-phase reaction between vinyl chloride and excess ozone. A noise-equivalent concentration of 50 ppb and a linear response up to 10 ppm suggest use in monitoring employee exposure levels.

A small, lightweight monitor for ambient carbon monoxide has been developed under contract. The detection of carbon monoxide is based on the nondispersive optical absorption technique of gas filter correlation. A noise-equivalent concentration of 20 ppb represents an order of magnitude improvement over current commercial instrumentation. The instrument operates at atmospheric pressure, is not sensitive to flow rates, and requires no additional gases.

Future programs will be directed to developing an absolute calibration for ozone based on ultraviolet spectroscopy. In addition, a program to exploit fluorescence methods to measure nitrogen dioxide and sulfur dioxide has recently been initiated. These fluorescence devices, if perfected, have the potential of being lower in cost and more reliable than current procedures being used to monitor sulfur dioxide and nitrogen dioxide.

Emission Measurements Research

Selection of Criteria for Stationary Source Measurement Strategies—This activity consists of efforts to develop performance criteria for prescribed methods and monitoring systems and to establish test procedures by which criteria can be verified.

Performance specifications and test procedures were developed as guidelines for continuous emission monitors of sulfur dioxide nitrogen oxides and visible particulate matter (opacity). The specifications and procedures were based on results of field studies in which commercially available monitors were evaluated at several industrial sources. A technical publication on these specifications and procedures provided the basis for their use as guidelines for monitoring systems in support of New Source Performance Standards (NSPS) and State Implementation Plans. Studies are continuing to provide similar technical documentation for emission monitors for carbon monoxide water soluble fluorides, hydrogen sulfide, hydrocarbons, total reduced sulfur, and mass of particulate matter. Additional effort is continuing in evaluating the applicability of the present monitoring guidelines to additional source industries identified in upcoming regulations and modifying the guidelines for these industries if necessary on an industry-by-industry basis.

Reference measurement methods have been prescribed in the *Federal Register* in support of NSPS. Equivalent and alternative methods have been defined, but their acceptance is subject to the approval of the EPA Administrator. Activity is underway to provide technical data on the criteria and procedures for assessing the acceptability of any proposed equivalent or alternative method. Reference measurement methods under evaluation include those for emissions of particulate mass, sulfur dioxides, nitrogen dioxide, total fluorides, hydrogen sulfide, and sulfuric acid mist. The evaluations involve field studies of the methods applied to specific source-pollutant combinations identified in the NSPS.

Stationary Source Particulate Emissions—This activity consists of efforts to develop new and improved technology for measurement of the mass, composition, and size distribution of airborne particles emitted from stationary sources. Considerable progress was made in each of these areas in 1974.

Several continuous particle mass emission monitors based on the beta gauge technique were evaluated at a coal-fired and an oil-fired power plant, a cement plant, and a ferro-alloy plant. In-stack transmissometers for monitoring flue opacity and for indirect measurement of particle mass emissions were evaluated at coal- and oil-fired power plants, a cement plant, a sewage sludge incinerator, an asphalt concrete plant, a refinery, and a lead/brass smelter.

A prototype instrument was developed for continuous measurement of size distributions of particle emissions in the size range from 0.1 to 10 microns in diameter. Based on the cascade impinger principle, the device also collects size fractions for further chemical and physical analysis.

Two X-ray fluorescence spectrometer instruments were developed for laboratory and field use, respectively. One is a multispectrometer system capable of rapid elemental analysis of filter-deposited particle samples on a large scale. The other is a compact, portable instrument applicable for on-site analysis of samples collected in the field.

Problems associated with the sampling of airborne particle emissions are also being studied. Efforts include: design and development of stack probes for efficient and representative sampling, development of an automatic isokinetic sampling system, stack gas velocity measurement, and sampling under conditions of tangential and low-velocity flow.

Stationary Source Gaseous Emissions—During 1974, the NSPS reference method for measurement of nitrogen oxides was evaluated and efforts for its improvement were undertaken. Sulfur dioxide instrumentation activities included: evaluation of a continuous monitor on a power plant with wet-scrubber control equipment, development of a low-cost extractive monitor, development of an *in situ* gas filter correlation spectrometer with multipollutant monitoring capability, design and construction of a remote monitor for sulfur dioxide in plumes, evaluation of a polymeric membrane dilution sampling system, and the development of a piezoelectric sorption detector.

Other activities included: the evaluation of odor measurement methods in four selected industries, design and development of a system for sampling and analyzing hydrocarbons, establishing effective extractive stack sampling procedures, acquiring a data base on techniques in order to establish monitoring specifications for sulfuric acid mist, and evaluation of the laser-Doppler technique for remote sensing of stack gas velocity.

Emissions of Hazardous Substances—The first group of substances designated for National Emission Standards for Hazardous Air Pollutants (NESHAP) includes asbestos, beryllium, and mercury. Future designations may include such materials as toxic metals (Pb, Cd, V, Ni, Co, Cr, Mn, As, and Se) or groups of polycyclic organic matter (POM). The purpose of this work is to develop measurement methods to obtain reliable emission data and to support emission standards for these substances.

In 1974, reference methods on beryllium and mercury were evaluated and the applicability of mercury monitors to emissions from selected industrial source categories was investigated. Studies are underway to develop technology for sampling and analyzing emissions of POM and polychlorinated biphenyl compounds. A procedure using scanning electron microscopy was developed for identification and measurement of airborne asbestos fibers, and a new X-ray diffraction method was found to be feasible for rapid quantitative analysis of airborne asbestos samples.

Mobile Source Emission Measurements—Activities in this program include the definition, description, and measurement of emissions from all mobile sources. Possible emissions are investigated and techniques for their measurement are developed. Emphasis is on currently nonregulated emissions that might have the greatest impact on our environment. Techniques for the measurement of regulated emissions are continually reviewed to ensure their efficacy.

In the past year, methods have been developed for the routine measurement of sulfate emissions from catalyst-equipped and noncatalyst vehicles. The techniques were also applied successfully to emissions from diesel automobiles. Previously developed technology for detailed hydrocarbon analysis was applied routinely to light-duty vehicle emissions and techniques to measure oxygenated components were delineated. Wet chemical methods for sulfur dioxide were adapted for use with vehicles, followed by efforts to develop instrumental techniques. Efforts are also underway to develop methods to measure hydrogen sulfide and other sulfur compounds in exhausts.

Methods for trace analysis of such nitrogen compounds as hydrogen cyanide and cyanogen were developed, and work is in progress to develop a satisfactory method for ammonia. A prototype gas filter correlation spectrometer was built for the measurement of methane, carbon monoxide, and carbon dioxide, and the design and construction of second instrument for analysis of other gases such as sulfur dioxide, ammonia, and formaldehyde is in progress. An atomic oxygen chemiluminescence technique shows promise as a possible method for assessment of exhaust gas reactivity.

An advanced prototype particle emission mass monitor, based on the beta-ray attenuation principle, was developed and is being evaluated. Several dilution tunnels for sampling particle emissions from light- and heavy-duty vehicles were designed and built and are in routine use. Efforts are in progress to develop sampling and measurement capability for particle emissions from aircraft turbines.

Mobile Source Emission Characterization—This program provides basic information needed in identifying and assessing potential hazards resulting from the introduction of new vehicles, fuels, and emission control technology. Efforts in 1974 centered on the development of such information for fuel and fuel additive control and for assessing the effects of oxidation catalysts on emissions from light-duty vehicles.

Extensive experimental data were obtained on emissions from 1975 prototype and production catalyst-equipped and noncatalyst passenger cars. Results showing significant increases in sulfate emissions due to catalyst use formed the basis for initial projections of future impact on air quality. Engine dynamometer tests of various commercial catalyst packages showed considerable differences in tendency to produce sulfate and suggested possible technology changes for minimizing sulfate emissions.

Detailed studies have been carried out for the detection of emissions of trace quantities of possible new gaseous compounds derived from the use of several fuel additive packages in passenger vehicles. No new compounds have as yet been identified.

A study was carried out to determine concentrations of unregulated emissions from light-duty diesel cars; substances measured included particulate matter, aldehydes, and sulfates. Sulfate emissions, present in significant amounts, correlated well with fuel sulfur level and depended also on driving mode.

Heavy-duty diesel particulate and gaseous emissions are being studied to determine the influence of diesel fuel properties and additives on emissions. Since the Federal 13-mode test is being used as a basis for these measurements, the effect of each of these model operating conditions is being studied as well. Information developed thus far includes the elemental composition of diesel soot and of the organic fraction of that material, a molecular weight distribution for the paraffinic fraction as an index of the volatility of the organic fraction, and detailed analysis of benzo(a) pyrene, phenols, and results on trace analysis of nitrogen-bearing species. This program is continuing with analyses for sulfate emissions.

LEGISLATIVE MANDATE

The program of the Chemistry and Physics Laboratory is totally responsive to the legislative mandates of the Clean Air Act of 1970. The research and development program relates to many of the sections of the Act as specifically detailed below.

> **"RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES**
>
> **"Sec. 103. (a) The Administrator shall establish a national research and development program for the prevention and control of air pollution and as part of such program shall—**
>
> **"(1) conduct, and promote the coordination and acceleration of, research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, and control of air pollution; . . .**
>
> **"(3) conduct investigations and research and make surveys concerning any specific problem of air pollution in cooperation with any air pollution control agency with a view to recommending a solution of such problem, if he is requested to do so by such agency or if, in his judgment, such problem may affect any community or communities in a State other than that in which the source of the matter causing or contributing to the pollution is located;"**

Each year the Chemistry and Physics Laboratory conducts one or more field studies of air pollution. During 1974 a field study was conducted in Denver, Colorado, in cooperation with the EPA Regional Office and the State air pollution control agency. The study was part of a continuing effort to determine the nature and source of the Denver "Brown Cloud." Researchers also conducted field studies in West Virginia, Ohio, and New York to assess the transport of oxidants and oxidant precursors; and in St. Louis to determine the character and origin of aerosols and assess their effects.

> **"(4) establish technical advisory committees composed of recognized experts in various aspects of air pollution to assist in the examination and evaluation of research progress and proposals and to avoid duplication of research . . ."**

The Chemistry and Physics Laboratory provides administrative management of the Air Pollution Chemistry and Physics Advisory Committee. The Committee met twice in 1974: first in San Francisco, where the principal agenda item was oxidant abatement strategies; and second at the Research Triangle Park, North Carolina, where the main subjects were oxidant transport studies, atmospheric sulfuric acid and sulfates studies, and automotive emission studies.

> **"(f) (1) in carrying out research pursuant to this Act, the Administrator shall give special emphasis to research on the short- and long-term effects of air pollutants on public health and welfare. In the furtherance of such research, he shall conduct an accelerated research program . . .**
>
> **"B) to improve knowledge of the short- and long-term effects of air pollutants on welfare."**

Research on the effects of air pollutants on materials and on atmospheric visibility is part of the CPL program. In 1974 a study was completed in which several critical materials were exposed to simulated polluted atmospheres in chambers. The study produced preliminary dose/response information.

> **"RESEARCH RELATING TO FUELS AND VEHICLES**
>
> **"Sec. 104. (a) The Administrator shall give special emphasis to research and development into new and improved methods, having industrywide application, for the prevention and control of air pollution resulting from the combustion of fuels . . .**
>
> **"(b) In carrying out the provisions of the section, the Administrator may—**
>
> **"(1) conduct and accelerate research and development of low-cost instrumentation techniques to facilitate determination of quantity and quality of air pollutant emissions, including, but not limited to, automotive emissions; . . .**
>
> **"(3) establish and operate necessary facilities and test sites at which to carry on the research, testing, development, and programming necessary to effectuate the purposes of this section; . . . ."**

CPL researchers continued to improve existing and develop new methods and instruments for assessing air pollutant emissions. Developments related to ambient air measurements included several methods for assessing particulate matter (size distribution and elemental analysis); sulfuric acid mist; X-ray fluorescence measurement of trace elements; laser powered long-path spectrophotometers to analyze for CO, O_3, SO_2, and other pollutants; a simple sensitive monitor for vinyl chloride; and a lightweight monitor for CO. Developments concerning the measurement of emissions from stationary sources included new and improved technology for assessing particulate mass, composition and size distribution; the introduction and evaluation of new techniques related to SO_2 monitoring; and the evaluation of odor measurement methods. Automotive emission developments included the routine measurement of sulfate emissions from catalyst-equipped and non-catalyst vehicles and diesel automobiles; improved techniques for measuring hydrocarbons, oxygenated components, SO_2, CO, and CO_2; methods for measuring trace amounts of hydrogen cyanide and cyanogen; and an advanced prototype particle emission mass monitor. Complete engine dynamometer test facilities are available to support automotive emission research.

> **"AIR QUALITY CRITERIA AND CONTROL TECHNIQUES**
>
> **"Sec. 108. (a) (1) For the purpose of establishing national primary and secondary ambient air quality standards . . .**
>
> **"(2) The Administrator shall issue air quality criteria for an air pollutant within 12 months after he has included such pollutant in a list under paragraph (1). Air quality criteria for an air pollutant shall accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare which may be expected from the presence of such pollutant in the ambient air, in varying quantities. The criteria for an air pollutant, to the extent practicable, shall include information on—**
>
> **"(A) those variable factors (including atmospheric conditions) which of themselves or in combination with other factors may alter the effects on public health or welfare of such air pollutant;**
>
> **"(B) the types of air pollutants which, when present in the atmosphere, may interact with such pollutant to produce an adverse effect on public health or welfare; and**
>
> **"(C) any known or anticipated adverse effects on welfare . . .**
>
> **"(c) The Administrator shall from time to time review, and as appropriate, modify, and reissue any criteria or information on control techniques issued pursuant to this section . . . ."**

CPL continued a program on analytical methods and instruments to be used as portable analyzers (dosimeters) in health studies to aid in revision of air quality criteria. Effects of air pollutants on organic and inorganic materials were investigated in environmental chambers to supply input for developing or modifying secondary standards for the criteria pollutants. Research on new particulate mass monitoring instrumentation will provide a more acceptable reference or equivalent method for total suspended particulates. Considerable effort is going into the development of the measurement technology for fine particles and for other pollutants that may be considered candidates for air quality criteria. The formation and decay of such pollutants as vinyl chloride and halocarbons (Freons) are under intense investigation.

> **"NATIONAL AMBIENT AIR QUALITY STANDARDS**
> **"Sec. 109. (a) (1) The Administrator—**
> **"(A) within 30 days after the date of enactment of the Clean Air Amendments of 1970, shall publish proposed regulations prescribing a national primary ambient air quality standard and a national secondary ambient air quality standard for each air pollutant for which air quality criteria have been issued prior to such date of enactment; and**
> **"(B) after a reasonable time for interested persons to submit written comments thereon (but no later than 90 days after the initial publication of such proposed standards) shall by regulation promulgate such proposed national primary and secondary ambient air quality standards with such modifications as he deems appropriate . . .**
> **"(b) (1) . . . Such primary standards may be revised in the same manner as promulgated."**

CPL researchers conducted a number of field and chamber studies in support of present national ambient air quality standards (particularly those of hydrocarbon/oxidants and nitrogen dioxide) to further define the atmospheric relationships involving hydrocarbons and oxidants. Researchers also developed and improved instruments for continuously measuring air pollutants.

> **"IMPLEMENTATION PLANS**
> **"Sec. 110. (a) (1) Each State shall, after reasonable notice and public hearings, adopt and submit to the Administrator, within nine months after the promulgation of a national primary ambient air quality standard (or any revision thereof) under section 109 for any air pollutant, a plan which provides for implementation, maintenance, and enforcement of such primary standard in each air quality control region (or portion thereof) within such State. In addition, such State shall adopt and submit to the Administrator (either as a part of a plan submitted under the preceding sentence or separately) within nine months after the promulgation of a national ambient air quality secondary standard (or revision thereof), a plan which provides for implementation, maintenance, and enforcement of such secondary standard in each air quality control region (or portion thereof) within such State. Unless a separate public hearing is provided, each State shall consider its plan implementing such secondary standard at the hearing required by the first sentence of this paragraph."**

CPL is involved in a considerable effort to support the development of chemical and physical air pollution models for reactive pollutants for use in implementation plans, including site criteria of large area sources. The transport of oxidants and the rural oxidant problem are under investigation. Empirical relationships between hydrocarbons and oxidants (such as upper limit curves) and relationships between hydrocarbons and nitrogen dioxide are being reviewed and evaluated. Reactivities of hydrocarbons and other organics have been evaluated for organic solvent regulations and transportation plans.

> **"STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES**
> **"Sec. 111. (b) (1) Within 120 days after the inclusion of a category of stationary sources in a list under subparagraph (A), the Administrator shall publish proposed regulations, establishing Federal standards of performance for new sources within such category. The Administrator shall afford interested persons an opportunity for written comment on such proposed regulations. After considering such comments, he shall promulgate, within 90 days after such publication, such standards with such modifications as he deems appropriate. The Administrator may, from time to time, revise such standards following the procedure required by this subsection for promulgation of such standards. Standards of performance or revision thereof shall become effective upon promulgation."**

Extensive support is provided by CPL in verifying and improving reference measurement methods for new source performance standards. Performance criteria have been developed for extractive and *in-situ* instrumentation to determine compliance with various pollutant standards for a number of sources.

> **"NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS**
> **"Sec. 112. (b) (1) (B) Within 180 days after the inclusion of any air pollutant in such list, the Administrator shall publish proposed regulations establishing emission standards for such pollutant together with a notice of a public hearing within thirty days. Not later than 180 days after such publication, the Administrator shall prescribe an emission standard for such pollutant, unless he finds, on the basis of information presented at such hearings, that such pollutant clearly is not a hazardous air pollutant. The Administrator shall establish any such standard at the level which in his judgment provides an ample margin of safety to protect the public health from such hazardous air pollutant."**

CPL is responsible for developing the analytical methodology for the national emission standards for hazardous pollutants. Improved methods of sampling and analysis are under investigation or evaluation for asbestos, mercury, beryllium, and polychlorinated biphenyl compounds. There has been extensive development of X-ray fluorescence methods for use in analyzing a number of elements possibly having a hazardous nature. Improved sampling and more rapid analysis methods for polycyclic organic matter are under development. Researchers developed a simple sensitive monitor for vinyl chloride.

> **"PART A – MOTOR VEHICLE EMISSION AND FUEL STANDARDS**
>
> **"Sec. 202. (a) Except as otherwise provided in subsection (b)—**
>
> **"(1) The Administrator shall by regulation prescribe (and from time to time revise) in accordance with the provisions of this section, standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines, which in his judgment causes or contributes to, or is likely to cause or to contribute to, air pollution which endangers the public health or welfare . . .**
>
> **"(b) (2) Emission standards under paragraph (1), and measurement techniques on which such standards are based (if not promulgated prior to the date of enactment of the Clean Air Amendments of 1970), shall be prescribed by regulation within 180 days after such date.**
>
> **"(e) In the event a new power source or propulsion system for new motor vehicles or new motor vehicle engines is submitted for certification pursuant to section 206 (a), the Administrator may postpone certification until he has prescribed standards for any air pollutants emitted by such vehicle or engine which cause or contribute to, or are likely to cause or contribute to, air pollution which endangers the public health or welfare but for which standards have not been prescribed under subsection (a)."**

Measurement technology is being developed and evaluated for regulated and nonregulated emissions from on-the-road vehicles and advanced power sources. New and improved instrumentation has been developed for measuring regulated pollutants. Extensive research has been done to evaluate emission characteristics of a number of prototype and production catalyst-equipped and non-catalyst passenger cars. Special emphasis was placed on sulfate emissions.

> **"REGULATION OF FUELS**
>
> **"Sec. 211. (b) (2) For the purpose of registration of fuels and fuel additives, the Administrator may also require the manufacturer of any fuel or fuel additive—**
>
> **"(B) to furnish the description of any analytical technique that can be used to detect and measure any additive in such fuel, the recommended range of concentration of such additive, and the recommended purpose-in-use of such additive, and such other information as is reasonable and necessary to determine the emissions resulting from the use of the fuel or additive contained in such fuel, the effect of such fuel or additive on the emission control performance of any vehicle or vehicle engine, or the extent to which such emissions affect the public health or welfare . . .**
>
> **Tests under subparagraph (A) shall be conducted in conformity with test procedures and protocols established by the Administrator. The result of such tests shall not be considered confidential.**
>
> **"(c) (1) The Administrator may, from time to time on the basis of information obtained under subsection (b) of this section or other information available to him, by regulation, control or prohibit the manufacture, introduction into commerce, offering for sale, or sale of any fuel additive for use in a motor vehicle or motor vehicle engine (A) if any emission products of such fuel or fuel additive will endanger the public health or welfare, or (B) if emission products of such fuel or fuel additive will impair to a significant degree the performance of any emission control device or system which is in general use, or which the Administrator finds has been developed to a point where in a reasonable time it would be in general use were such regulation to be promulgated.**
>
> **"(2) (C) No fuel or fuel additive may be prohibited by the Administrator under paragraph (1) unless he finds, and publishes such finding, that in his judgment such prohibition will not cause the use of any other fuel or fuel additive which will produce emissions which will endanger the public health or welfare to the same or greater degree than the use of the fuel or fuel additive proposed to be prohibited."**

CPL provides support in developing emission protocols for fuel additives effects. CPL also performs the emission characterization of nonregulated emissions from advanced alternate power systems. Considerable work was done on the problem of sulfate formation by exhaust oxidation catalyst systems. Work continued on alternate automotive power systems such as the Wankel engine and the passenger vehicle diesel engine.

> **"ADDITIONAL REPORTS TO CONGRESS**
>
> **"Sec. 313. Not later than six months after the effective date of this section and not later than January 10 of each calendar year beginning after such date, the Administrator shall report to Congress on measures taken toward implementing the purpose and intent of this Act including, but not limited to, (1) the progress and problems associated with control of automotive exhaust emissions and the research efforts related thereto; (2) the development of air quality criteria and recommended emission control requirements; (3) the status of State ambient air standards setting, including such plans for implementation and enforcement as have been developed; (5) the extent of development and expansion of air pollution monitoring systems; (6) progress and problems related to development of new and improved control techniques; (7) the development of quantitative and qualitative instrumentation to monitor emissions and air quality; (8) standards set or under consideration pursuant to title II of this Act; (9) the status of State, interstate, and local pollution control programs established pursuant to and assisted by this Act; and (10) the reports and recommendations made by the President's Air Quality Advisory Board."**

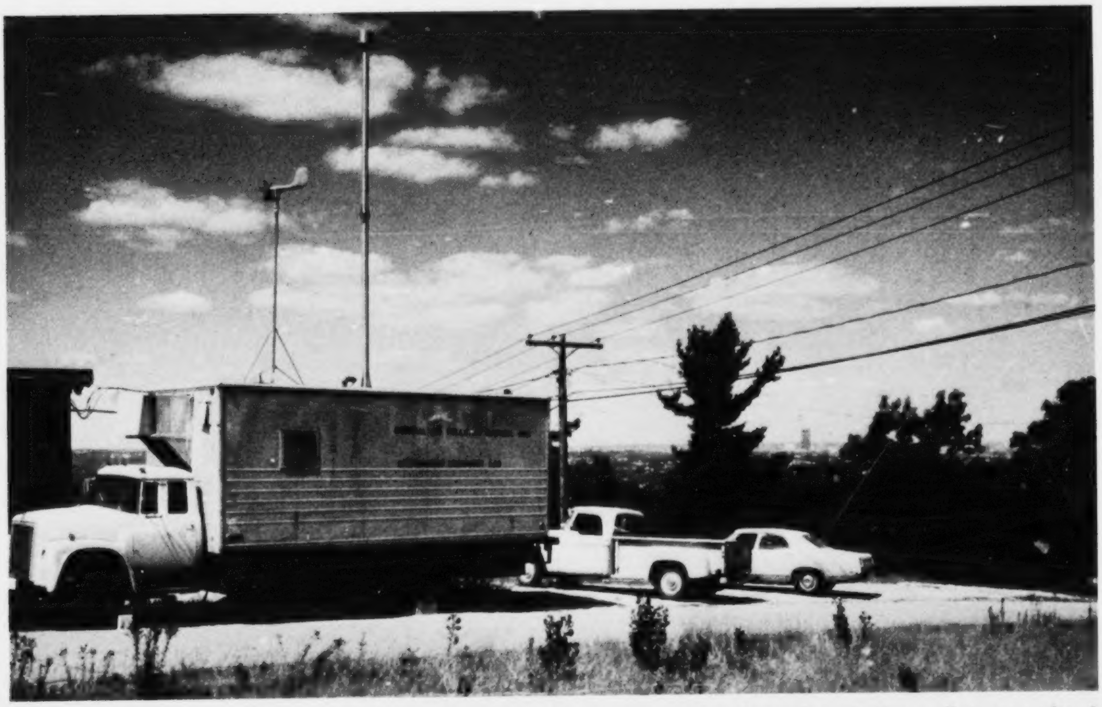
Technical support is provided by CPL in developing air quality criteria documents and progress reports required by Congress on air quality, emission instrumentation, and emission standards for moving vehicles.

Table 13 contains a summary of resources employed by CPL for Fiscal Year 1975 in support of applicable sections of the Clean Air Act.

Table 13. SUMMARY OF RESOURCES FOR CHEMISTRY AND PHYSICS LABORATORY FOR FISCAL YEAR 1975

Section of Clean Air Act Supported	Funds, $\$10^3$
103	956
108	1,808
109	901
110	1,922
111	1,959
112	516
202	758
211	1,520
313	333
Total	10,673[a]

[a] Total does not include $2.065 million of special energy appropriations.



Ground and airborne sampling of ozone and other oxidants was conducted to determine whether pollutants emitted in New York City are transported to Boston.

Meteorology Laboratory

OVERVIEW OF ML MISSION

The Meteorology Laboratory (ML) provides an accurate description of the role and interrelationships of atmospheric processes in effective air, water, and land resource management. It provides direct consultation and technical meteorological services; and, through grants, contracts, and personal contacts, promotes meteorological research in concert with EPA's efforts to improve and protect public health and welfare.

ML's contribution to efforts to control air pollution lies in the delineation of the effects of weather and climate on air pollution as well as the effects of air pollution on weather, visibility, and climate. Theoretical and experimental research into the physical processes that affect the transport, diffusion, transformation, and disposition of air pollutants in and from the atmosphere leads to improved techniques for determining and forecasting meteorological aspects of air pollution on a local, regional, or national basis. To this end, the Laboratory develops, evaluates, and disseminates analytical diffusion models, which are used to predict the temporal and spatial distribution of air pollutants. ML also develops sensing techniques for measuring meteorological parameters in urban and rural areas and provides meteorological support to EPA offices and activities in their abatement and compliance efforts.

ORGANIZATION

The Meteorology Laboratory consists of five Branches: Model Development, Environmental Applications, Climatic Analysis, Regional Air Pollution Study (RAPS), and Special Projects. The activities and research programs of these five Branches in furtherance of the Laboratory's mission are described briefly below.

Model Development Branch

The Model Development Branch develops the analytical and numerical formulations (i.e., meteorological dispersion and statistical techniques models) that are used to estimate relationships between source emissions having any specified distribution and the resultant air quality throughout any specified region. The Branch also conducts theoretical and experimental studies to improve the understanding of physical processes affecting the transport, diffusion, transformation, and ultimate disposition of pollutants in and from the atmosphere.

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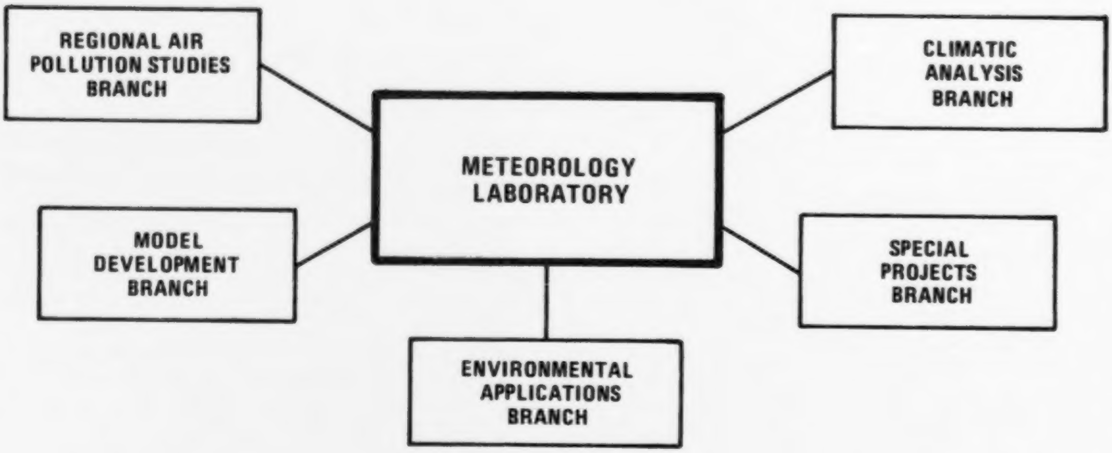


Environmental Applications Branch

The Environmental Applications Branch evaluates new and existing meteorological dispersion and statistical techniques and models and adapts them to recurring user applications. The Branch maintains liaison with groups applying and developing models to provide guidance and advice and to ascertain future model needs at the user level.

Climatic Analysis Branch

The Climatic Analysis Branch develops and applies techniques of meteorological data analysis and presentation to provide information on the potential for atmospheric dispersion of air pollutants in a specific geographical area. The Branch determines empirical relationships between air quality data, meteorological parameters, physical processes governing observed air quality, and site characteristics. Through a national and international cooperative network, Branch personnel monitor atmospheric turbidity and establish seasonal values, geographical variations, and long-term trends. Field experiments are designed and conducted to determine the radiant energy balance of earth-atmosphere systems in both urban and rural locations. The Branch evaluates and studies the collected data by incorporating them into radiation transfer theories for variously polluted and clean atmospheres, and thereby establishes effects of pollutants on the energy balance, which then affects pollutant distribution.

Regional Air Pollution Studies (RAPS) Branch

The Regional Air Pollution Studies Branch develops, implements, and manages a comprehensive research program to define and describe air pollution transport and transformation processes in the atmosphere on a regional scale. It coordinates the activities of other agencies, both public and private, that are conducting field experiments pertinent to RAPS to ensure that the broad program of research, development, and field experimentation directed toward the acquisition, verification, and evaluation of basic data for models used to describe and predict the transport, dispersion, and concentration of pollutants in the regional area is conducted in an appropriate and economical manner.

Special Projects Branch

The Special Projects Branch provides continuing technical guidance and staff support to EPA components, including the Regional offices, to ensure that appropriate meteorological information is provided in abatement, compliance, and other operational activities. The Branch collects and evaluates environmental quality and meteorological-climatological information appropriate for application to power plant or industrial engineering requirements, design of monitoring networks, support of legal actions, and studies of possible effects of air pollution. In support of EPA Regional Offices, consultation and other meteorological assistance is provided

Solar tracking instruments are used to track the sun, measure the intensity of solar radiation, and indirectly provide a measure of atmospheric aerosol concentration.

to State and local air pollution control agencies. Field support is provided in air pollution emergencies. Liaison is maintained with the National Weather Service through participation in the work of interagency committees.

PHYSICAL FACILITIES

In addition to the usual meteorological instrumentation, the Laboratory possesses a mobile lidar (laser-radar) unit, a microwave thermosonde system, an acoustic radar system, special sensors for studying surface energy fluxes, and special equipment for sensing short- and long-wave radiation. Sunphotometers used in the national and international turbidity networks are tested, repaired, calibrated, and occasionally built in the Laboratory.

Weather teletype and facsimile products, which yield up-to-date hourly forecasts and weather information for the entire U.S. are received within the Laboratory.

The Fluid Modeling Facility (FMF) was dedicated in November 1974. Presently, the FMF consists of a large sophisticated wind tunnel with a test section that is 3.66 meters (12 feet) wide, 2.13 meters (7 feet) high, and 18.29 meters (60 feet) long with a maximum airflow speed of 7.62 meters (25 feet) per second. A smaller wind tunnel is available for calibration and response testing of wind measuring instruments. A water channel/towing tank with a test section 1.1 meters (3.5 feet) deep, 2.4 meters (8 feet) wide, and 24.4 meters (80 feet) long is under construction. In the towing tank mode of operation, stratified layers of salt water will be used to simulate atmospheric stability. The water channel/towing tank is expected to become operational in late 1975. The FMF, one of only a few of its kind in the world, is available to other EPA components—including Regional Offices – State air pollution control agencies, and other Federal agencies. The facility is designed to provide fast response to questions on pollutant dispersal in complex flow situations, from stacks, and from automobiles in various highway configurations.

MAJOR PROGRAM AREAS

Meteorology Laboratory activities can be functionally divided into five areas: development, evaluation, and validation of air quality models; innovative development in air quality simulation models; determination of patterns and levels of pollutant emissions from large power plants; determination of pollutant and thermal emission effects on visibility, weather, and climate; and meteorological support for abatement and compliance efforts.

Unless indicated otherwise, the research activities discussed in the following paragraphs represent continuing efforts by ML or its contractors in support of Section 103 of the Clean Air Act.

Air Quality Models

Information on the meteorological effect of pollutant concentrations on prospective control strategy decisions and land-use plans is provided by models describing temporal and spatial variations in air quality. To facilitate the application of models, the air quality simulation models and related data for various pollutants are stored at a central computer facility, called the User's Network of Applied Models of Air Pollution (UNAMAP).

- APRAC—Provides the hourly average carbon monoxide level as a function of extraurban diffusion from automotive sources in upwind cities, intraurban diffusion from roadway sources, and local diffusion within a street canyon.
- HIWAY—Estimates highway-related air pollution for receptor locations that are downwind of at-grade and cut highway sections.
- CDM—Provides long-term average pollutant concentration.
- PTMAX—Estimates the maximum hourly average ground-level concentration from a single stack as a function of stability and wind speed.
- PTDIS—Estimates the hourly average ground-level concentration from a single stack at a specified downwind distance.
- PTMTP—Estimates the average hourly concentration at up to 30 receptors from up to 25 sources.

A new UNAMAP tape and appropriate forms have been submitted to the National Technical Information Center, Springfield, Virginia, replacing current tapes. The new tapes include batch versions of the six UNAMAP models and interactive versions of HIWAY and the three point source models. Batch versions of the UNAMAP progress are being placed on the EPA's UNIVAC computer; information to operate these programs should be available in early 1975.

Atmospheric turbidity is measured using a portable sunphotometer developed at Meteorology Laboratory.

Reactive Pollutant Models

The continuation of photochemical air quality simulation model development proceeded via one large contract effort with Systems Applications, Inc., based on the evaluation of the results and techniques employed in three models. In assessing the validity of urban air-shed models employing trajectory or grid point approaches, it has been concluded that: (1) the neglect of horizontal diffusion in the trajectory approach introduces only minor errors; (2) the neglect of the vertical wind component in the trajectory approach can lead to significant errors; (3) the neglect of wind shear in the vertical in the trajectory approach can be a serious source of error; (4) the error in the grid point model, due to finite differencing, under worse-case conditions may produce absolute errors of about 50 percent for a 9-hour simulation.

Using various statistical techniques, an analysis of past model verification studies has been performed. The results show that none of the photochemical models adequately represents the observed data for NO, NO_2, and O_3; but in the case of CO, two of the models (Systems Application, Inc. (SAI) and Geophysical Research Corp. (GRC)) were acceptable. Definite inadequacies in the chemical kinetic mechanisms used in simulating photochemical smog formation were indicated.

The first phase of the photochemical model modification for multi-day simulation was completed. Modifications in the SAI program have been made enabling multi-day simulations of carbon monoxide concentration distributions. Sensitivity studies performed on the grid point model show major effects caused by variations in wind speed and radiation intensity, moderate effects caused by variations in mixing depth and emission rate, and slight effects caused by variation in vertical diffusivity.

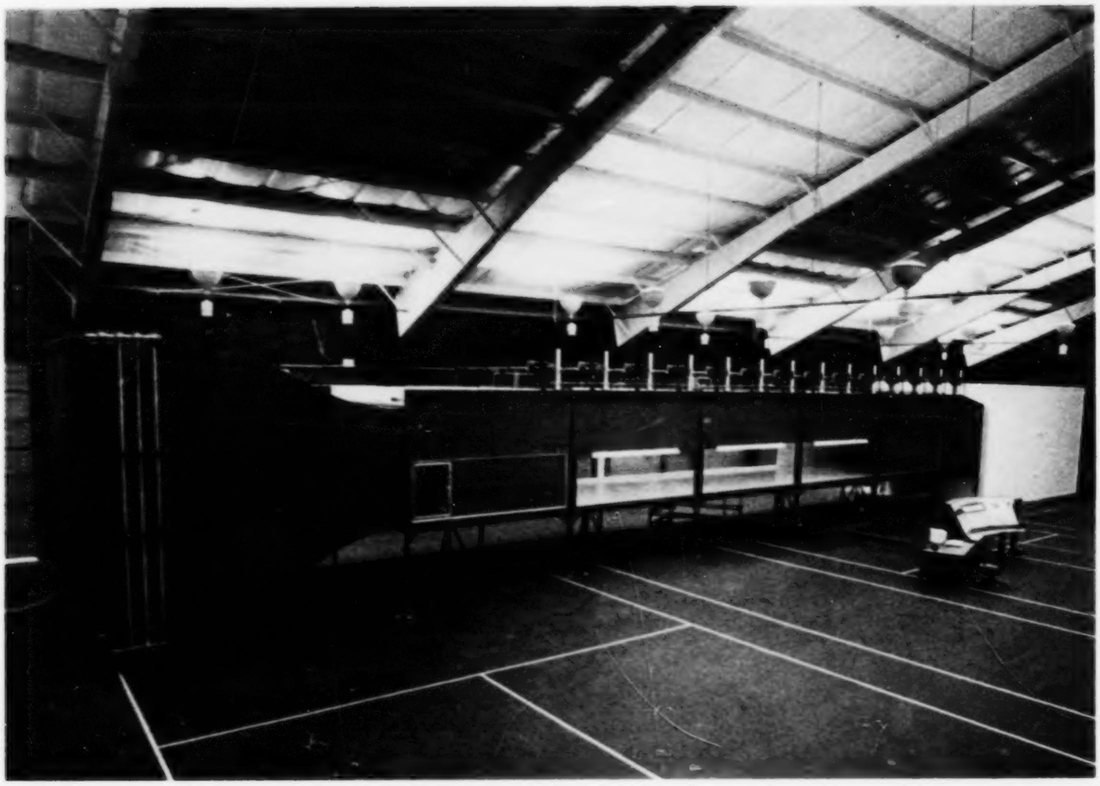
Additional Modeling Work

The Meteorology Laboratory's effort in inert pollutant modeling includes:

- Development of the real-time episode model (REM).
- Initial evaluation of a highway model for describing dispersion from automobiles using photographic techniques and smoke generators on two model cars on a track constructed in a wind tunnel.
- The conduct of a series of field studies of fumigation of pollutants from tall stacks within the lake-breeze circulation area.
- Twenty-four periods of intensive field investigation of the formation and breakup of the nocturnal urban boundary layer conducted in St. Louis in August 1974, with measurements of temperature and moisture profiles during the mid-afternoon measured by aircraft.
- Revision of the *HIWAY Users' Manual* study showing how arithmetic mean particulate sulfate concentrations could be related to short-term effects.
- Publication of an air quality data analysis system for interrellating effects, standards, and needed source reductions.
- Modification of the batch version of the PTMTP model to permit calculation of sulfate concentrations from sulfur dioxide levels.
- Modifications to the batch model for point, area, and line sources to include the variation in wind height as an optional feature.

In-house research focused on an investigation of $SO_2 \rightarrow SO_4^=$ transformation in power plant plumes. The model uses a Gaussian plume approximation to model diffusion dynamics and a chemical kinetic mechanism for the simulation of an SO_2-NO_X-CO-H_2O-air system.

Pennsylvania State University, under an EPA grant, conducted studies in: the development of mesoscale air pollution related prediction models; modeling of planetary boundary layer turbulence and structure; the analysis of acdar (acoustic-radar) signals for wind and temperature measurements in the planetary boundary layer; studies of atmospheric aerosol properties and aerosol-atmospheric interactions; and aircraft measurements of urban and regional scale mesoscale aerosol, turbulence, and radiation distribution. Under an EPA grant, a study of the spatial variability of airborne pollen concentrations was completed by the State University of New York at Albany. Technology Service Corporation, under EPA contract, has developed a repro-modeling technique to the analysis of a photochemical air quality simulation model, developed by Systems Applications, Inc., (SAI); the repro-model, using a piecewise linear regression technique, develops regression equations for oxidant, NO_X, and NO_2 for several grid squares using five aggregate input variables from the SAI model as dependent variables. Documentation of lidar studies of stack plumes in rural and urban environments was completed by Stanford Research Institute under EPA contract; documentation of a numerical model of the urban atmosphere by the University of California at Davis, also under EPA grant, was completed. Field studies by the Battelle Pacific Northwest Laboratories, under EPA contract, on the precipitation scavenging of inorganic pollutants from metropolitan sources, have demonstrated that precipitation scavenging by convective storms can be an extremely effective mechanism for the removal of urban pollutants from the atmosphere. Measurements made at various distances "downwind" of an urban area (St. Louis) indicate that precipitation scavenging removal rates can be comparable to urban emission rate estimates. Field studies were conducted by the Tennessee Valley Authority, under EPA interagency agreement, to develop and evaluate a kinetic model to describe the chemical reactions occurring in a plume under various meteorological conditions. Studies conducted in the St. Louis area by the University of Wyoming, under EPA grant, suggest that the increased rainfall observed downwind of St. Louis was due to dissipation of storms over the urban area resulting from the absence of a moisture source in the urban area; the equivalent was lower over the metropolitan area than over the countryside, indicating the differences in atmospheric moisture content between the city and countryside.



Wind tunnel studies provide information on pollutant dispersal characteristics in the atmosphere.

JRB Associates, Inc., under EPA contract, has documented a methodology for treating localized emissions of reactive pollutants. Other studies presently being carried out by EPA contractors for the Meteorology Laboratory include: the development and evaluation of a dry deposition model through the measurement of deposition velocities for gaseous pollutants and using profile measurement techniques in field studies; the formulation of criteria for model evaluation and improvement compatible with performance requirements or desiderata for air quality, based on the examination and evaluation of pertinent laws, regulations, and judicial decisions; the reduction and collation of the 1964-1967 New York University Air Pollution Project data; the simplification of the invariant model developed by Aeronautical Research Associates of Princeton, Inc., for use as a closure scheme in complex meteorological air quality numerical models; the development of a spectral numerical model of turbulent diffusion in an incompressible, density-stratified fluid; the definition of the three-dimensional flow field over complex terrain under stably stratified conditions, through experiments in a towing tank; the development and evaluation of an advanced air quality simulation model, including improved parameterization of turbulent diffusion and adaptation of the model for use in the St. Louis area; the analysis of lidar measurements made in the Los Angeles Basin to depict the depth of the mixing layer.

Geophysical Studies and Climatic Effects

This work area encompasses the analysis of pollutant effects of physical processes in the atmosphere, the comprehensive examination and statistical analysis of air pollution meteorology parameters, and the assessment of the effect of meteorological and climatological parameters on air quality. Statistical, numerical, and experimental methods were used to investigate the effects of air quality on meteorology and climatology, and to assess the effects of meteorology and climatology on air quality.

As part of a comprehensive photochemical pollution field experiment conducted in the fall of 1973 in the Los Angeles Basin, the Meteorology Laboratory measured solar radiation (incident global all-wave and UV, 300 to 380 nm wavelengths) at six sites in the Los Angeles Basin. Five of the sites were located in the urban area between Los Angeles International Airport and San Bernardino; the sixth site was located on pollution-free Mt. Disappointment at 6000 ft MSL. Initial analysis of radiation data collected continuously from August 30 through November 7, 1973, indicates that the effect of atmospheric pollution in the Basin was to reduce the incident UV energy by some 25 to 35 percent during poor visibility situations, based on comparative measurements at Mt. Disappointment. Both the atmospheric turbidity and incident radiation data showed marked diurnal variations corresponding to the photochemical pollution cycle.

Other geophysical studies by contractors include: measurements of atmospheric aerosols using photometric measurement of solar and lunar aureoles, utilizing observations made at 500 and 700 nm to estimate aerosol size distribution; initial measurements of oxidant concentrations on a TV tower located on Mt. Sutro in San Francisco to obtain background concentrations; aerosol scavenging by precipitation, determined theoretically and confirmed experimentally; and examination of the effects on air quality changes in aircraft operation during landings and takeoffs.

The Meteorology Laboratory continued administration of a global atmospheric turbidity network and the updating of air pollution potential climatologies.

The Regional Air Pollution Study (RAPS) is a planned 5-year effort to develop, improve, and validate mathematical air quality simulation models on a regional scale. It encompasses studies of emission, transport, transformation, and removal processes affecting the form and distribution of air pollutants. A spectrum of models resulting from the study will find applications in such air resources management areas as development of control strategies and land use planning. The study is being carried out in the St. Louis, Missouri-Illinois, region.

To provide the input for model development, two major areas of data-acquisition activities are under way. To provide the extensive data base of air quality and meteorological measurements against which model calculations may be compared, a 25-station telemetering network, the Regional Air Monitoring System (RAMS), was installed and put into operation during the year. All stations measure NO, NO_2, O_3, CO, CH_4, total HC, aerosol light scatter, temperature, dewpoint, and wind direction and speed. Half the stations measure SO_2, H_2S, and total gaseous sulfur, with the other half measuring total sulfur only. At selected stations, devices for measuring turbulence, vertical temperature difference, solar and sky radiation, and total suspended particulate were installed. The stations are operated remotely by a central computer facility to which the stations are linked by telephone lines; the central computer also serves as the principal data-acquisition facility, polling the stations once each minute, and storing the data for subsequent processing. In addition to the telemetering network, two sites were activated to routinely make meteorological soundings. Every 6 hours, radiosondes are released and tracked to obtain temperature, humidity, and winds aloft. At hourly intervals between the radiosonde releases, pilot balloons are released and tracked to obtain the winds aloft only.

The other major type of activity consists of experiments designed to determine processes and process rates, particularly in areas of transport and dispersion, transformation, and local pollutant variability. Field experiments are designed to be carried out concurrently to the maximum extent possible, in order to make best use of the material and personnel resources required to perform these experiments. A limited field exercise was carried out in February 1974, and a major exercise was concentrated in July and August, when more than 200 investigators and supporting personnel were engaged in component studies. Most of these studies are described more fully in this section and in the section from the Chemistry and Physics Laboratory.

Two EPA components outside ORD-RTP also have important roles in the RAPS. Under the direction of the National Air Data Branch of EPA's Office of Air Quality Planning and Standards, development of the RAPS emission inventory data base has progressed with no major problems. Work to date has concentrated on development of methodologies for the various types and groupings of sources leading to the emission parameters that will be used to derive the emission data. In addition, contacts were made with companies responsible for the major individual sources of pollutant emissions in the St. Louis area; hourly monitoring data for almost all major sources are now being obtained.

ORD's Environmental Monitoring and Support Laboratory at ERC-Las Vegas provides three large helicopters and associated personnel for support of field studies. Two complete instrument packages and data-acquisition systems were assembled and installed in two of the helicopters to provide measurements of the same air quality parameters that are measured at the RAMS sites; the third helicopter serves as a backup. By the end of the summer exercise, both instrumented helicopters were in operation in St. Louis. A second series of helicopter measurements was made in November, providing a vertical extension of the RAMS at the time that system was first brought up to full operation.

All data obtained in the study will be entered in the RAPS data bank, utilizing the UNIVAC 1110 system at RTP. The major content of this bank will be data from the RAMS; procedures to ensure the validity of such data are under development. Data from experimental studies will also be included, but will often require further processing and analyses before being put into final format for the data bank. Software for insertion, updating, and retrieval of all emission and aerometric data is currently under development.

METEOROLOGY SUPPORT

In support of Sections 110, 303, and 315 of the Clean Air Act, the Meteorology Laboratory provides technical services to various EPA offices and programs and to State and local agencies. The Laboratory also supplies meteorological field support during emergency episodes involving critical air pollution incidents. NOAA meteorologists were assigned to: the Monitoring and Data Analysis Division and the Control Programs Development Division of EPA's Office of Air Quality Planning and Standards, the Environmental Monitoring and Support Laboratory, and the Health Effects Research Laboratory at ORD-RTP; the Environmental Monitoring and Support Laboratory at Las Vegas; the ORD Laboratories at Corvallis, and six Regional Offices.

During 1974 the Laboratory provided technical support in the following areas: estimated changes in human exposure to suspended sulfate attributable to equipping light-duty motor vehicles with oxidation catalysts; calculated expected oxidant and carbon monoxide concentrations from years 1965 to 2000 for downtown areas of large metropolitan areas; applied averaging-time model and air management steps to severe air pollution problems in southern Poland; evaluated increased air pollution levels resulting from a potential switching of existing power plants from low sulfur oil to coal; calculated annual maximum nitrogen dioxide concentrations for various averaging times and standard geometric deviations for sites that would exactly achieve the present national ambient nitrogen dioxide standard; calculated particulate sulfate concentrations at selected sites throughout the U.S. and projected future concentrations as a function of expected growth and various potential control strategies; estimated ambient sulfate levels downwind of power plants resulting from SO_2 and sulfate releases; developed a computer technique to compute the expected return period for violating the national ambient air quality standards, as a function of the number of air samples available, when the highest observed concentration is used as the "design" value for achieving these standards; developed graphical and computer techniques to calculate the expected number of hours that a national ambient air quality standard would be exceeded if the second highest sample in a year is given; computed expected ocean-level air concentrations of HC1 resulting from the burning of hydrocarbon wastes aboard the incinerator ship Vulcanus; calculated carboxyhemoglobin concentrations in nonsmokers in Los Angeles and Milwaukee on each day of the year; offered advice regarding past and future studies of a smelter in Missouri, assisted in the site selection for the New York State Department of Environmental Conservation highway study.

OFFICE OF AIR QUALITY PLANNING AND STANDARDS SUPPORT

During 1974 the Laboratory continued to provide meteorological support to the Office of Air Quality Planning and Standards. Meteorological expertise was applied in studies concerned with the impact of state implementation plans on available supplies of low-sulfur coal. A dispersion model was applied to selected power plants in 20 states to determine if the low-sulfur coal deficit could be alleviated by selective granting of variances. Also, considerable effort was devoted to determining the need for flue gas desulfurization or low-sulfur fuel versus the use of tall stacks or supplementary control systems (SCS).

An acceptable SCS is expected to control stack emissions on the basis of (1) field studies, (2) timely ambient measurements, (3) mathematical models, (4) meteorological forecasts, and (5) technical experience.

Dispersion analyses were conducted to estimate the air quality impact of a wide variety of industrial source emissions. All criteria pollutants as well as lead, mercury, beryllium, and polyvinyl chlorides were included in these analyses. The sources were considered in both controlled and uncontrolled modes.

Meteorologists were active in the preparation of guidelines that are used to determine whether anticipated growth in an area will cause national ambient air standards to be endangered and whether a given maintenance plan will meet requirements. Meteorologists are also involved in the development of methodologies and guidelines for the evaluation of proposed SCS.

Air quality and emission trends published during the year showed a downward trend for most major pollutants in urban areas, but no discernible trend in rural areas. A meteorological analysis of the data showed a statistically significant relationship between upward trends in total suspended particulate (TSP) and decreasing rainfall over large geographic areas.

With meteorological support, EPA continued intensified investigations to determine the cause of nonurban concentrations of ozone that have exceeded the 1-hour standard of 160 $\mu g/m^3$ (0.08 ppm).

Ozone levels are being correlated with National Weather Service upper air and surface data. The objective of this analysis is to determine the significance of upwind trajectories, spatial variations of relevant meteorological variables, and frontal passages.

LEGISLATIVE MANDATE

The major Laboratory effort is directly related to the requirements of Section 103 of the Clean Air Act; however, efforts are also in support of Sections 110, 303, and 313. Pertinent portions of these Sections are quoted below, followed by brief discriptions of the types of supportive actions taken by ML.

> **"RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES**
>
> **Sec. 103. (a) The Administrator shall establish a national research and development program for the prevention and control of air pollution and as part of such program shall—(1) conduct, and promote the coordination and acceleration of, research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, and control of air pollution; . . ." (3) conduct investigations and research and make surveys concerning any specific problem of air pollution in cooperation with any air pollution control agency with a view to recommending a solution of such problem, if he is requested to do so by such agency or if, in his judgment, such problem may affect any community or communities in a State other than that in which the source of the matter causing or contributing to the pollution is located; . . . . "(b) In carrying out the provisions of the preceding subsection the Administrator is authorized to—**
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> **"(1) collect and make available, through publications and other appropriate means, the results of and other information, including appropriate recommendations by him in connection therewith, pertaining to such research and other activities.**
>
> **"(2) cooperate with other Federal departments and agencies, with air pollution control agencies, institutions, and organizations, and with any industries involved, in the preparation and conduct of such research and other activities;**
>
> **"(3) make grants to air pollution control agencies, to other public or nonprofit private agencies, institutions, and organizations, and to individuals, for purposes stated in subsection (a) (1) of this section;**
>
> **"(4) contract with public or private agencies, institutions, and organizations, and with individuals . . .;**
>
> **"(7) collect and disseminate, in cooperation with other Federal departments and agencies, and with other public or private agencies, institutions, and organizations having related responsibilities, basic data on chemical, physical, and biological effects of varying air quality and other information pertaining to air pollution and the prevention and control thereof; . . .**
>
> **"(f) (1) In carrying out research pursuant to this Act, the Administrator shall give special emphasis to research on the short- and long-term effects of air pollutants on public health and welfare. In the furtherance of such research, he shall conduct an accelerated research program— . . . (B) to improve knowledge of the short- and long-term effects of air pollutants on welfare.**
>
> **"(2) In carrying out the provisions of this subsection the Administrator may— . . . (C) utilize, on a reimbursable basis, the facilities of existing Federal scientific laboratories and research centers; (D) utilize the authority contained in paragraphs (1) through (4) of subsection (b); and (E) consult with other appropriate Federal agencies to assure that research or studies conducted pursuant to this subsection will be coordinated with research and studies of such other Federal agencies."**

EPA's research responsibilities, as outlined in the portions of the Clean Air Act cited above, constitute the Meteorological Laboratory's principal mission. The Laboratory also provides direct assistance in the evaluation of environmental impact statements.

> **"IMPLEMENTATION PLANS**
>
> **"Sec. 110. (a) . . . (2) The Administrator shall . . . approve or disapprove such (state-submitted implementation) plan or any portion thereof. The Administrator shall approve such plan, or any portion thereof, if he determines that it was adopted after reasonable notice and hearing and that— . . . (C) it includes provision for establishment and operation of appropriate devices, methods, systems, and procedures necessary to (i) monitor, compile, and analyze data on ambient air quality . . ."**

Laboratory assistance provided by the Meteorological Laboratory in support of the evaluation and enforcement of state implementation plans by EPA is a component of Section 110 of the Clean Air Act.

> **"EMERGENCY POWERS**
>
> **"Sec. 303. Notwithstanding any other provision of this Act, the Administrator . . . may bring suit . . . to immediately restrain any person causing or contributing to (the) alleged pollution to stop the emission of air pollutants causing or contributing to such pollution or to take such other action as may be necessary."**
>
> **"ADDITIONAL REPORTS TO CONGRESS**
>
> **"Sec. 313 . . . the Administrator shall report to Congress on measures taken toward implementing the purpose and intent of this Act . . ."**

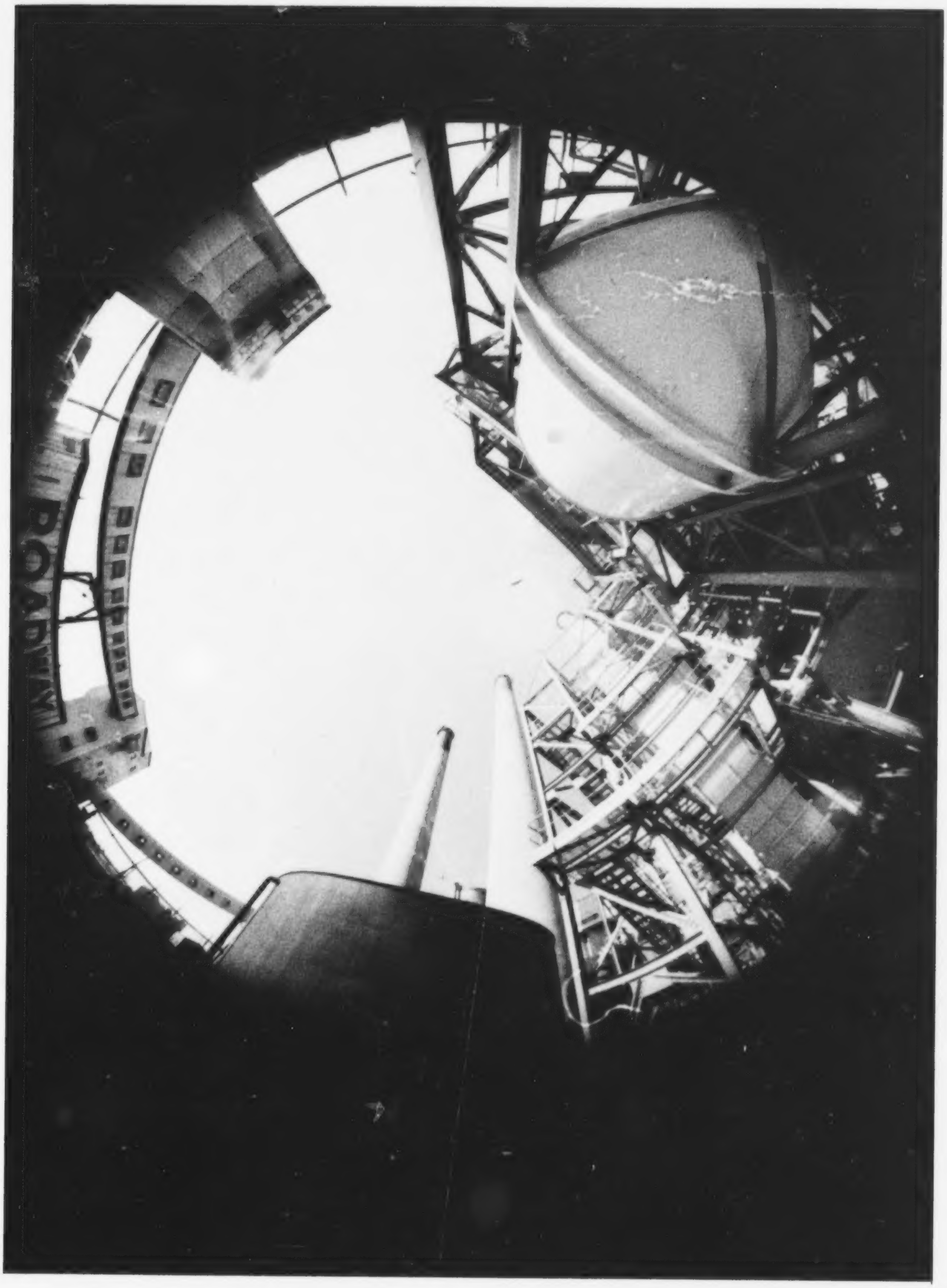
The Meteorological Laboratory provides direct support to EPA's exercise of emergency powers under Section 303 of the Clean Air Act. The Laboratory's assistance is also provided in support of Section 313 of the Clean Air Act to prepare meteorological portions of reports to Congress.

Table 14 contains a summary of the resources employed by ML for Fiscal Year 1975 in support of the applicable sections of the Clean Air Act.

Table 14. SUMMARY OF RESOURCES FOR METEOROLOGY LABORATORY FOR FISCAL YEAR 1975

Section of Clean Air Act Supported	Funds, $\$10^3$
103	3,268
110	330
303	33
313	50
Totals	3,681

Industrial
Environmental
Research
Laboratory


ROADWAY

Control Systems Laboratory

OVERVIEW OF CSL MISSION

The Control Systems Laboratory (CSL) of ORD-RTP is involved in a variety of technical and management functions directly related to the research, development, and demonstration of equipment and systems designed to abate, in a timely and cost-effective manner, the emission of atmospheric pollutants from stationary sources to a level that protects public health and welfare, and to do so within the framework of our nation's energy and environmental mandates. Included in this mission is the goal of developing a complete data base of stationary source emissions and demonstrating adequate technology to control pollutant emissions so that effective New Source Performance Standards and Hazardous Pollutant Standards can be promulgated.

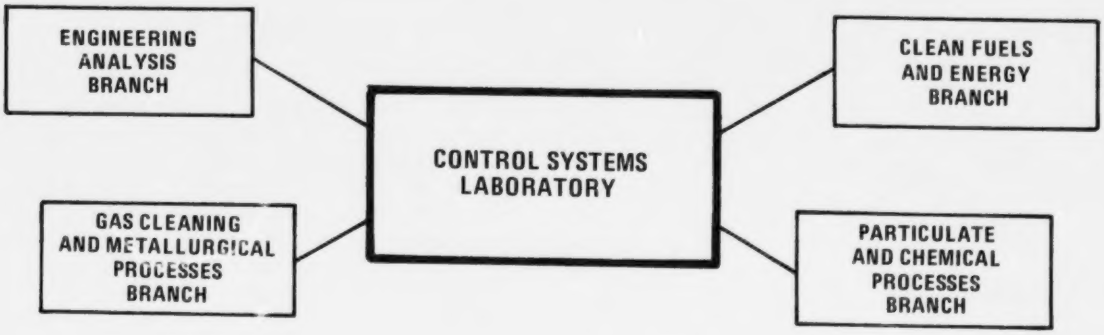
CSL has a high degree of expertise in the management of complex engineering research and development projects; additionally, as a result of more than 10 years of experience as an organizational entity, the Laboratory has developed other major capabilities in efforts to fulfill its mission:

- The Laboratory has become a technical information base to support EPA's decision-making capabilities in the area of stationary source air pollution control.
- The Laboratory has proven its ability to reconcile environmental and industrial requirements in a cost-effective manner by working with industry on joint programs to solve environmental problems.
- The Laboratory has become an international forum for communication concerning available technology through its recognized ability to objectively evaluate new concepts and to share research results.

ORGANIZATION

The Control Systems Laboratory consists of four main Branches. Its Engineering Analysis Branch functions as a program monitoring and evaluation group. The other three Branches are engaged in projects ranging from small-scale experimental studies and exploratory research, through pilot-plant-size experimental work, to prototype evaluations of equipment large enough to permit confident scale-up to full-size commercial installations.

"Fish eye" view of a demonstration of the magnesia slurry scrubbing system installed at Boston Edison Company's Mystic Station.


ENGINEERING ANALYSIS BRANCH
CLEAN FUELS AND ENERGY BRANCH
CONTROL SYSTEMS LABORATORY
GAS CLEANING AND METALLURGICAL PROCESSES BRANCH
PARTICULATE AND CHEMICAL PROCESSES BRANCH

Gas Cleaning and Metallurgical Processes Branch

The Gas Cleaning and Metallurgical Processes Branch directs and manages a broad-based research, development, and demonstration program aimed at perfecting processes and equipment for the removal of gaseous pollutants from fossil-fuel combustion effluents and of all pollutants from primary and secondary operations in the ferrous and non-ferrous metals processing industries.

Much of the work of this Branch relates to flue gas scrubbing processes: lime/limestone wet scrubbing at TVA's Shawnee Plant, in Key West, and at CSL's North Carolina facilities; double alkali scrubbing, using a soluble alkali (usually sodium) solution; the Bahco process, using a unique 2-stage vertical scrubber; a 4-year sludge disposal program; Chemico Mag-Ox, a regenerable approach utilizing magnesium oxide; Wellman-Lord, utilizing a sodium sulfite/bisulfite solution with thermal regeneration; Stone and Webster/Ionics, utilizing sodium hydroxide solution with electrolytic regeneration; Monsanto Cat-Ox, a catalytic oxidation adaptation of the contact sulfuric acid process; a completely cyclic ammonium sulfite/bisulfite process with bisulfate regeneration; and a regenerable Citrate process. The Branch's metallurgy-related activities include such iron and steel industry areas as coke ovens, sinter plants, basic oxygen process (BOP) furnaces, and iron foundry cupolas, as well as work with pollutants from copper, lead, and zinc smelters, and pollutants from secondary aluminum furnaces.

Clean Fuels and Energy Branch

The Clean Fuels and Energy Branch is responsible for research, development, and demonstration (including evaluation) studies relating to processes for the production or utilization of clean fuels or clean energy as a means of air pollution control. Among its activities are: evaluation of systems for removing potential pollutants from coal and oil; critical air pollutant emission assessment and review of new energy technologies; development of generalized control technology for air pollutant emissions from fossil fuel combustion and conversion processes; evaluation and development of combustion modifications for abating the emission of nitrogen oxides and other combustible pollutants from all stationary combustion sources; and evaluation, environmental assessment, and/or development of new pollution-free methods of generating and utilizing energy.

Combustion modifications for the control of nitrogen oxides and other pollutants continue to be the target of significant efforts of Branch personnel. Modifications being investigated include: combustion with low excess air, recirculation of flue gas, staged combustion, combustor redesign, and fluidized-bed combustion. Investigations of fuel cleaning have included fossil fuels (coal, oil, and gas) and waste products such as municipal refuse.

The Branch's work with advanced, low-emission, energy-conserving systems includes a mobile demonstration unit (the EPA-Van) and a heat and emission loss prevention system (HELPS).

Particulate and Chemical Processes Branch

The Particulate and Chemical Processes Branch is active in three major areas: it identifies, develops, and demonstrates generalized particulate control technology to support the needs of CSL for technology to control particulate emissions from specific industries; it identifies, develops, and demonstrates technology for controlling pollutant emissions from the chemical process industries; and it provides process measurement services to all CSL Branches.

The Branch's work in the area of particulate control technology development has included studies not only to improve such conventional particulate control equipment as electrostatic precipitators, fabric filters, and wet scrubbers, but also to identify and further develop such completely new control approaches as the Aronetics two-phase scrubber, Sonic Agglomerator, Steam-Hydro scrubbers, CHEAF filter, foam scrubbers, and condensation scrubbers. Its activities related to the control of air pollution from chemical process industries include studies of a wide range of organic and inorganic manufacturing processes, combustion processes, and open sources. The Branch's process measurement activities encompass the selection, verification, and further development of sampling methods, analytical procedures, and process instrumentation required for CSL's internal and external research, development, and demonstration activities.

Engineering Analysis Branch

The Engineering Analysis Branch is the Laboratory's program planning and evaluation coordination facility. Additionally, it is responsible for technical and editorial services that are more effective when they are provided centrally. Branch personnel provide cost control and contract management services to individual project officers and assist in the evaluation of unsolicited proposals as well as in the review of on-going programs. Staff specialists are available for consultation on specific technical matters.

PHYSICAL FACILITIES

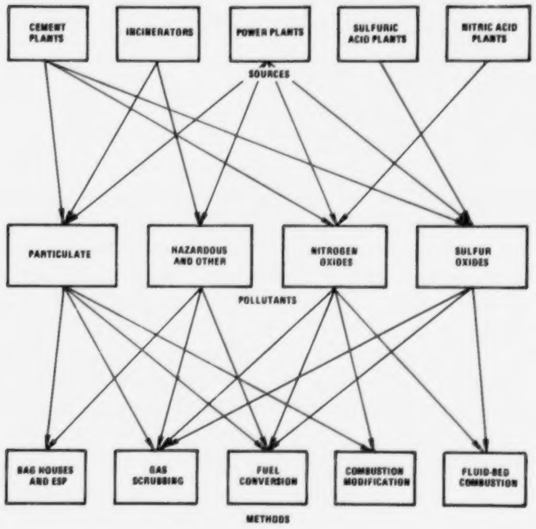
CSL's laboratory facilities include a flue-gas generator; bench-scale scrubbing equipment; laboratories for odor problem studies and for the physical characterization of particulates; an electronics shop; and equipment for wet and instrumental analyses. CSL also maintains and operates a self-propelled van and a trailer (both 40 feet in length) that are equipped to conduct full-scale investigation of process streams. .

Pilot-size equipment in the ORD-RTP High Bay Areas include a model wet scrubber; four baghouses for fabric filtration studies; a laboratory for the evaluation of novel particulate control devices; and a variety of experimental and commercial combustion systems including furnaces, boilers, and a gas turbine instrumented for most gaseous pollutant emission measurements. (Fuels being investigated are coals, oils, gases, and other liquid and gaseous materials.)

The Laboratory's in-house capability to support measurements programs recently took a significant step forward with the installation, at ORD-RTP, of the first aerodynamic test facility specifically designed for studies requiring large gas volumes (up to 15,000 cfm) with carefully controlled velocity profiles and known chemical composition.

MAJOR PROGRAM AREAS

The accompanying diagram, showing air pollution control technology interactions, presents an overview of the Control System Laboratory program. Because of the way various laws are written, and because of EPA's planning system, CSL's program is divided into



Air pollution control technology interactions among sources to which new source performance standards were first applied.

elements based on the control of individual pollutants. Obviously, however, to control ambient concentrations of pollutants, the industries producing the pollutants must be controlled.

The first five industries to which New Source Performance Standards were applied are shown at the top of the diagram. The methods that CSL is improving or developing for air pollution control are shown at the bottom of the diagram. Inevitably, there is significant overlap between industry, pollutant, and control method descriptions of CSL's program. For example, work directed toward controlling sulfur oxides (SO_x) may involve clean fuels, gas scrubbing, or advanced power cycles. On the other hand, SO_x gas scrubbing may be applicable to power plants, sulfuric acid plants, and non-ferrous smelters; and smelters may emit trace hazardous elements as well as SO_x.

For purposes of discussion, this portion of the Report is organized by control of specific pollutants. The broad applicability of a control method for more than one pollutant, from more than one source, should be kept in mind when analyzing the program. This interdependence of CSL program components highlights an important synergistic characteristic: for example, a change in the Laboratory's combustion control research program, to reflect changes in the nitrogen oxides (NO_x) program philosophy, will also affect CSL's program to control combustible particulates — particulates that may include carcinogenic hydrocarbons, possibly the most hazardous of pollutants.

A strong cooperative effort has been fostered between industry and government: CSL's major control technology development/demonstration projects have been cost-shared approximately equally by both sectors. Industrial studies conducted by the Laboratory have resulted in initiation of such promising projects as various flue gas desulfurization systems, advanced power cycles, low-Btu gasification, and coke pushing and charging demonstrations. Because many aspects of air pollution control are nearly equal in importance, CSL's efforts are not (and cannot be) concentrated in any single area.

Particulate Control

The most pressing need in particulate control technology is the development of commercially available and widely applicable fine particulate (between 0.01 and about 3 micrometers in diameter) control technology to support the establishment of Fine Particulate Ambient Air Quality Standards. Such technology is generally inadequate and currently in the early stages of development under EPA sponsorship. This technology is also acutely needed to achieve Hazardous Pollutant Standards and associated New Source Performance Standards for trace metals, which have already been established or are planned for the near future. In an effort to develop this technology as rapidly as possible, CSL is currently working with many (nearly 70) contractors, grantees, and consultants.

Scrubbers, electrostatic precipitators, and fabric filters are currently the major particulate collection devices. These devices are being up-graded by projects concerned with decreasing costs, increasing applicability of these devices to a wider range of sources, and extending their range of particle collection capability to smaller particle sizes. In addition, entirely new concepts of particle collection are being investigated.

System studies, completed for each of the conventional devices, define potential areas of improvement and new applications. Long range projects include: development of generalized models for existing collectors, identification and laboratory scale testing of totally new concepts in particle control technology, and pioneering work in small particle detection and small particle generation equipment.

Electrostatic Precipitation — In an electrostatic precipitator (ESP), dust suspended in the gas stream is electrically charged and passed through an electric field where electrical forces cause the particles to migrate toward a collection electrode. The dust, separated from the gas by being retained on the collection electrode, is subsequently removed from the device. In a conventional ESP, the dust is removed mechanically. In a wet ESP, the dust is removed by continuous washing of the collection electrode.

CSL is conducting field tests of industrial ESP's to determine the fine particle collection efficiency and economics of ESP systems. Recent results indicate that properly designed and operated ESP's are capable of controlling flyash from coal-fired utility boilers at an overall mass efficiency in excess of 99 percent. These same efficiency measurements indicate that these ESP's are more than 90 percent efficient on a mass basis in collecting all particle size fractions down to about 0.02 micrometers in diameter.

ESP's are being redesigned to improve their particulate collection efficiency, especially for fine particles and high resistivity dusts. This work includes development of special dust-conditioning methods, particle charging procedures, and collection section designs. The work on conditioning has resulted in the discovery of the current-carrying mechanism in flyash at high temperatures and the demonstration of a new conditioning agent.

Fabric Filtration – A typical fabric filter consists of a flexible layer of porous cloth through which a dust-laden gas is passed to separate particles from the gas stream. Fabric filters have been used successfully for many years to collect dusts at temperatures as high as about 290°C; however, comparatively little scientific effort has been expended to develop higher temperature filtration technology. Fabric filtration is one of the few techniques now capable of collecting very small particulate matter. Fabric filters are usually flat or tubular bags suspended in a structure known as a baghouse (see accompanying figure).

One product of a fabric filter systems study, completed for CSL in 1970, is a technology handbook intended as a guide in the design, development, application, and operation of fabric filter systems. The study also recommended research and development for possible funding by EPA.

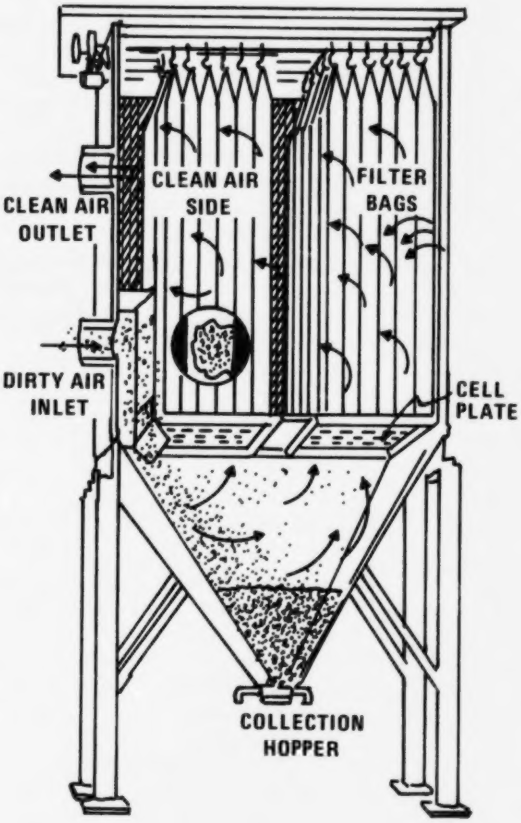
Products of that research over the period of this Report have been publications that relate woven fabric structure to filtering performance and evaluate new spunbonded nylons as filter media. Experimental work to aid in selecting optimum filter cleaning methods has been completed; a report of that work will be issued early in 1975.

Major effort has been directed toward characterizing and improving fabric filter system performance for capture of fine particulates. Tasks in this area have been awarded to contractors and grantees, as well as being pursued in-house. Specific programs involve the development of non-woven media; the development of high-velocity, high-efficiency filtration techniques; and the construction of a portable baghouse system for on-site field testing.

Novel Particulate Collection Devices – The cost of high-efficiency particle collection from industrial sources by conventional equipment of all types (scrubbers, filters, ESP's) is high, in large part because the efficiency of most collectors decreases in the fine particulate range. This performance loss must, therefore, be offset by large size or high-energy input. Devices or systems based on new collection principles or on radical redesign of conventional collectors are sometimes offered by private developers. Presently proposed systems include sonic agglomeration, granular bed filtration, foam scrubbing, and several types of steam or high-pressure water ejector scrubbers. Entirely new concepts utilizing new mechanisms have the potential for providing high-efficiency fine particle collection or for permitting the growth of particles by agglomeration for subsequent more efficient collection. New concepts that have been advanced include charged droplet scrubbing and collection of charged particles by fiber beds.

All known novel devices and new collection concepts are being reviewed by EPA. Those showing potential for fine particle collection will be evaluated for performance and related cost. Systems showing promise of high-efficiency fine particle collection at reasonable cost and meriting further development will, if necessary, be further supported by CSL. Pilot-scale demonstration projects were begun in FY 1975 on a charged droplet scrubber and a condensation scrubber.

Wet Scrubbing – In a wet scrubber, both gaseous and particulate pollutants are transferred from the gas to the scrubbing liquid. The availability of a wide variety of scrubber types and scrubbing liquids gives wet scrubbers the potential for satisfactorily removing many pollutants.



Typical fabric filter baghouse.

Sulfur Oxides Control

In the area of sulfur oxides (SO_x) control, achievement of Ambient Air Quality Standards demands the control of industrial combustion, industrial processes, and area sources, as well as utility combustion. Natural low-sulfur fuels are only sufficient to satisfy about 40 percent of the demands of State Implementation Plans. The remainder must be supplied by control technology in the form of effluent desulfurization, fuel cleaning, or process modification. Although the currently defined SO_x control technology program contains developmental projects of sufficient diversity to ensure the achievement of Ambient Air Quality Standards, a substantial EPA research and development investment will be required to bring this technology to commercial fruition. Only in the case of effluent desulfurization technology for electric utility applications will the control technology achieve widespread commercialization within the next few years.

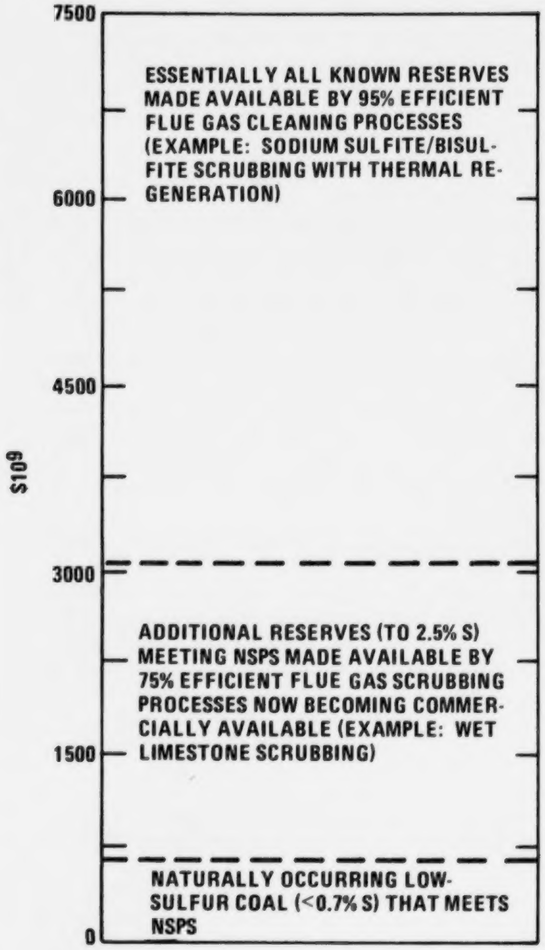
Consistent with Congressional guidelines, CSL's major concern has been the control of sulfur oxides from fuel combustion. About 80 percent of the Laboratory's total expenditures to date have been in this area and have been concentrated on flue gas cleaning. Flue gas cleaning devices are now being installed on commercial power plants in this country. The prototype demonstrations that CSL has underway are shown in Table 15. Except for clean fuels, flue gas cleaning is probably the only sulfur oxides control technique that will have widespread application within the next 10 to 15 years. With the expected shortage of clean fuels (amounting to about 20 percent of the coal demand), flue gas cleaning should find wide application.

The need to develop techniques to permit the use of eastern and midwestern coal is shown clearly in the accompanying figure. Only about 7 percent of this coal is usable under New Source Performance Standards. Because of physical and contractual limitations it is not possible to mine all the low sulfur coal first. (That is, the mining will proceed from left to right, not from bottom to top.) Thus a native resource approximating the GNP will not be available for use if cleaning techniques are not utilized. It had been projected that this would cause economic dislocations and unemployment, substantial increase in the flow of dollars outside the country, and increased dependence of the security of our country on Mid-eastern oil; current events substantiate that projection.

Flue gas cleaning provides an alternative (to low-sulfur coal and oil) that is both available and, in most instances, more economical than "clean" fuels. A detailed study, recently completed by TVA under EPA sponsorship shows that flue gas desulfurization costs range from 2 to 5 mills/kWh for full-scale systems on coal-fired plants. In general, the low end of the estimate can be associated with power plants larger than 500 MW. Estimates for oil-fired applications are slightly less than for equivalent coal-fired

Table 15. PRESENT AND PROJECTED FLUE GAS CLEANING DEMONSTRATIONS

Process and application	Startup	Removal efficiency, %
Wet limestone scrubbing		
Shawnee-TVA (30 MW, coal)	April 1972	75-90
Key West (40 MW, oil)	January 1974	60-80
MgO scrubbing		
Chemico (155 MW, oil)	May 1972	85-90
Chemico (100 MW, coal)	July 1974	85-90
Cat-OX		
Monsanto (100 MW, coal)	April 1975	85-90
Wellman-Lord (115 MW, coal)	December 1975	90-95
Double alkali		
General Motors (30 MW, coal)	March 1974	85-95



Value of eastern and central coals meeting new source performance standards as a function of efficiency of flue gas cleaning processes (value of coal resources at $12 per ton).

units. Current low-sulfur fuel differentials of $7.50 to $10/ton of coal and $2 to $3/barrel of oil equal approximately 3 to 4 and 2.7 to 4 mills/kWh, respectively. Thus, for many applications (particularly for larger power plants) flue gas cleaning is the more economical solution to the sulfur oxides emissions problem.

Most of CSL's early coal desulfurization work was in the area of improving and evaluating physical cleaning methods for coal. With the overall potential of physical desulfurization and deashing of coal reasonably well established, this approach should have moderate applicability in reducing sulfur by 30 to 70 percent in specific coals. Ongoing work in this area includes washability testing, coal desulfurization and cleaning, and pollutant control evaluation and optimization. The most recent work is aimed at chemical desulfurization of coal and the problems of hazardous pollutants in fossil fuel.

Two factors – the major contribution of small coal- and oil-burning sources (area sources) to the degradation of ambient air quality and the severely limited supplies of low-sulfur fuels – indicate a need for clean fuel or coal conversion processes. CSL has provided funds to both the Bureau of Mines and the Office of Coal Research to assist in both the development of conversion and gasification processes that can provide clean fuels and the determination of environmental controls that will be required for these techniques.

Since 1967, CSL has been actively developing several versions of the fluidized-bed process for combustion of coal and residual oil as a means of economical pollution control in low cost steam and power generation. This combustion process has the capability of reducing pollutant emissions 95 percent for SO_2, 80 percent for NO_x, and 99 percent for particulates. In addition, the capital costs for such a plant would be 10 to 20 percent less than a conventional facility, and thermal discharge to watercourses can be reduced by 10 to 60 percent. Fluidized-bed combustion represents an attractive long-range solution to the control of pollutants from utility boilers.

The Laboratory is also conducting research into the control of emissions from smelters, iron and steel operations, kraft wood pulping mills, iron foundries, secondary aluminum furnaces, and other industrial sources of SO_x.

Nitrogen Oxides Control

On a national basis, approximately 50 percent of the emissions of nitrogen oxides (NO_x) are from combustion sources other than motor vehicles. For this reason, the CSL program is oriented heavily in the direction of combustion control. Control of stationary sources of NO_x will be necessary for achieving and maintaining Ambient Air Quality Standards as well as for establishing future New Source Performance Standards.

The main approach has been modification of the combustion process to reduce NO_x formation. Bench-scale work and field testing indicate that necessary control for the immediate future can be achieved by this method. In addition, stack gas cleaning processes are being evaluated and investigated on a small scale; results in this area, however, are not encouraging thus far.

A further complication in nitrogen oxides formation and control is that NO_x is formed from two discrete sources; that is, thermal fixation of nitrogen in combustion air to form "thermal NO_x" and a significant conversion of nitrogen compounds in fuel to form "fuel NO_x." Experimental work and field testing are showing promise for controlling both NO_x sources; however, it has not yet been determined that "fuel NO_x" control by combustion modification alone will be adequate to attain projected long term goals.

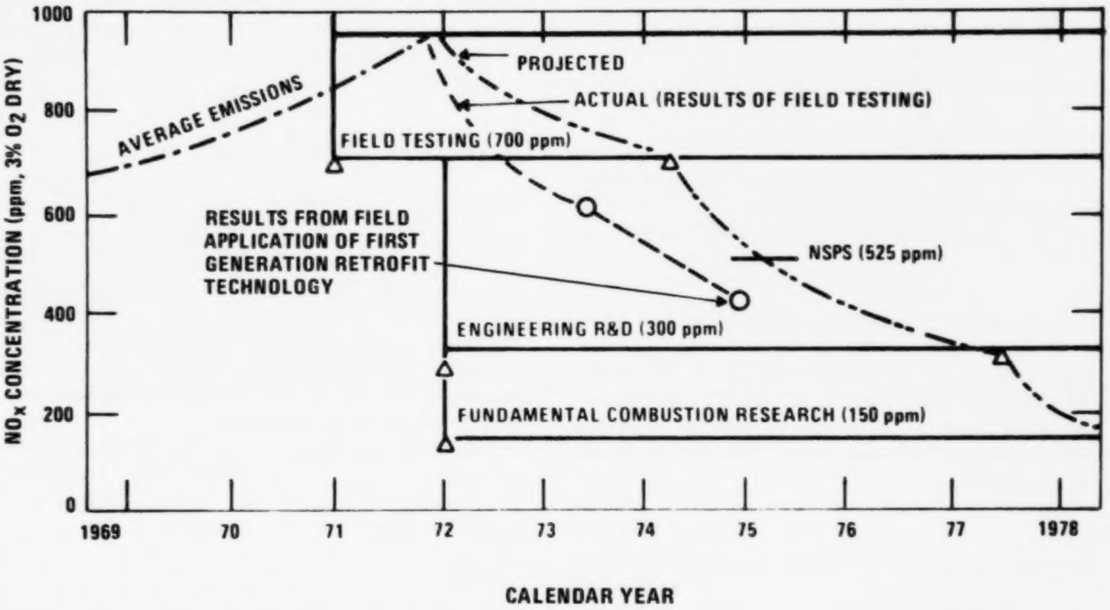
The accompanying figure shows another area in which CSL has made a major contribution – nitrogen oxides control in coal combustion, the most difficult area. The field testing program, which has been underway since the beginning of calendar year 1971, has been more effective than anticipated and is substantially ahead of schedule. The second part of the NO_x program, engineering research and development, began in calendar year 1974 and is expected to furnish technology permitting the attainment of National New Source Performance Standards during calendar year 1975. It should ultimately allow the attainment of average emissions of less than 300 ppm of NO_x.

The basic research, which got underway at the beginning of calendar year 1974, is expected to provide technology to allow average emissions of 150 ppm NO_x to be attained in 1978.

Primary efforts during 1975 will be the development and demonstration of modified operating procedures for NO_x control on pilot- and commercial-scale boilers. The efforts of the overall combustion research and development program are classified under the main areas of fundamental studies, fuel research and development, process research and development, and field testing.

Fundamental Studies – A number of projects classified as fundamental research studies are directed at providing a basic understanding of the important phenomena involved in the formation and desctruction of pollutants during the combustion process. This understanding can then be used to improve existing combustion control techniques and to suggest other techniques with even greater promise for control of pollutants. The fundamental studies cover three categories of work: the chemistry of pollutant formation and destruction, the physical processes of combustion, and the mathematical simulation of combustion.

The actual conditions existing within the flame zone are a function of the physical processes of combustion. Most combustors operate with diffusion flames where fuel and air are introduced separately and mixing is dependent on the manner of introduction. Because the flame zone is not of homogeneous composition, it is necessary to understand the role of combustion aerodynamics in pollutant formation. A contract with United Aircraft Research Laboratories



Control of nitrogen oxide emissions from coal-fired utility boilers.

has as its objective the establishment by detailed velocity mapping of the flow-field properties in an idealized single-burner combustor as a function of fuel and air inlet parameters. The local chemical compositions and the exhaust product composition will be monitored to show the effect of aerodynamic and mixing conditions. Future work in this area will include a study of the role of flame interactions in multiple-burner systems on the emission properties of the systems.

Because the chemical and physical effects of actual combustion are closely related, it is essential to provide a method of tying these effects together and generalizing the results for a variety of systems. Mathematical simulation of combustion by modeling is the tool used for this purpose. In the past year, work has been directed toward developing the necessary components of the model. Major effort has been expended in the development of a rapid computerized technique to allow evaluation of combustion kinetics of numerous simultaneous reactions, incorporation in the model of simplified flow fields, improvement of the turbulence model, and comparison of model predictions with cold- and hot-flow furnace data using simple chemical kinetics. Ultimately, the kinetics and fluid-flow programs must be applied together to give a realistic description of any practical system.

Fuels Research and Development – Fuels research and development studies are conducted on versatile experimental combustion systems. The studies are designed to develop generalized combustion control technology that is applicable to the control of NO_x and other combustion-related pollutants from conventional fuels, waste fuels, and future fuels. Studies conducted to date have been designed to develop combustion control technology for a specific fuel through single-burner design criteria on combustion modification techniques. These studies provide the future goals for NO_x control and will generate the necessary technology to be applied in the process research and development area.

Contracted studies with the Institute of Gas Technology (IGT) have been directed toward the relationship between combustion, aerodynamics, and pollutant emission characteristics of industrial gas burners. A recently initiated study with IGT will further investigate specific burner and process parameters and evaluate and optimize burner design to minimize NO_x emissions from natural gas firing. A new experimental furnace has been built for this program. The detailed experimental program will evaluate three classes of industrial natural gas burners. Detailed in-the-flame probing will be conducted to better understand the role of aerodynamics in pollutant formation. The experimental program and final report are scheduled for completion by mid-1975. Upon completion of the natural gas studies, combustion characteristics and emissions resulting from combustion of low-Btu gases will be evaluated.

Within the past year, EPA has contracted for the design, construction, and operation of a versatile, multi-burner furnace. This system is designed to simulate combustion conditions occurring in a variety of furnace types. The experimental work, scheduled to begin around July 1975, will evaluate and optimize a variety of combustion modifications and burner parameters designed to reduce NO_x and combustion-related pollutants. Fossil waste and new candidate fuels will be evaluated.

The International Flame Research Foundation is under contract to develop combustion system design criteria for heavy oil- and coal-fired furnaces. Two series of experimental trials have been conducted to relate burner design parameters to pollutant emissions, flame configuration, and combustion efficiency. These trials have consisted of input/output measurements followed by detailed flame probing for a limited number of cases. Results to date have identified the types of flow conditions required to control formation of NO_x from pulverized coal.

Process Research and Development – CSL's process research and development work involves studies with commercial and prototype combustion systems for the application of optimum NO_x control technology. Results of these studies will provide the basis for the demonstration of combustion control technology. To date, the studies have considered all conventional fuels and combustion systems. The major emphasis, however, is in controlling NO_x emissions from coal-fired utility boilers.

Two major programs that will have significant beneficial impact are those related to combustion modifications of a 125-MW, tangentially coal-fired utility boiler (Combustion Engineering, Inc.) and a 125-MW, wall coal-fired utility boiler (Tennessee Valley Authority). Both programs will evaluate staged combustion as a control technique for NO_x with special emphasis on unit performance and fire-side corrosion.

A program recently initiated with Combustion Engineering will evaluate staged combustion (overfire air) on coal-fired tangential boilers *designed* with this NO_x control technique. Two coal types (Western subbituminous and bituminous) will be studied. The test boilers are 450-MW units. This study should provide scale-up data on combustion modifications (from the on-going 125-MW tests) and relate the efficacy of retrofit technology to new unit design. Additionally, the study should give further insight to the role of fuel nitrogen and coal type and the degree of NO_x control achievable.

Advanced, low-emission, energy-conserving systems are demonstrated in EPA's mobile van.

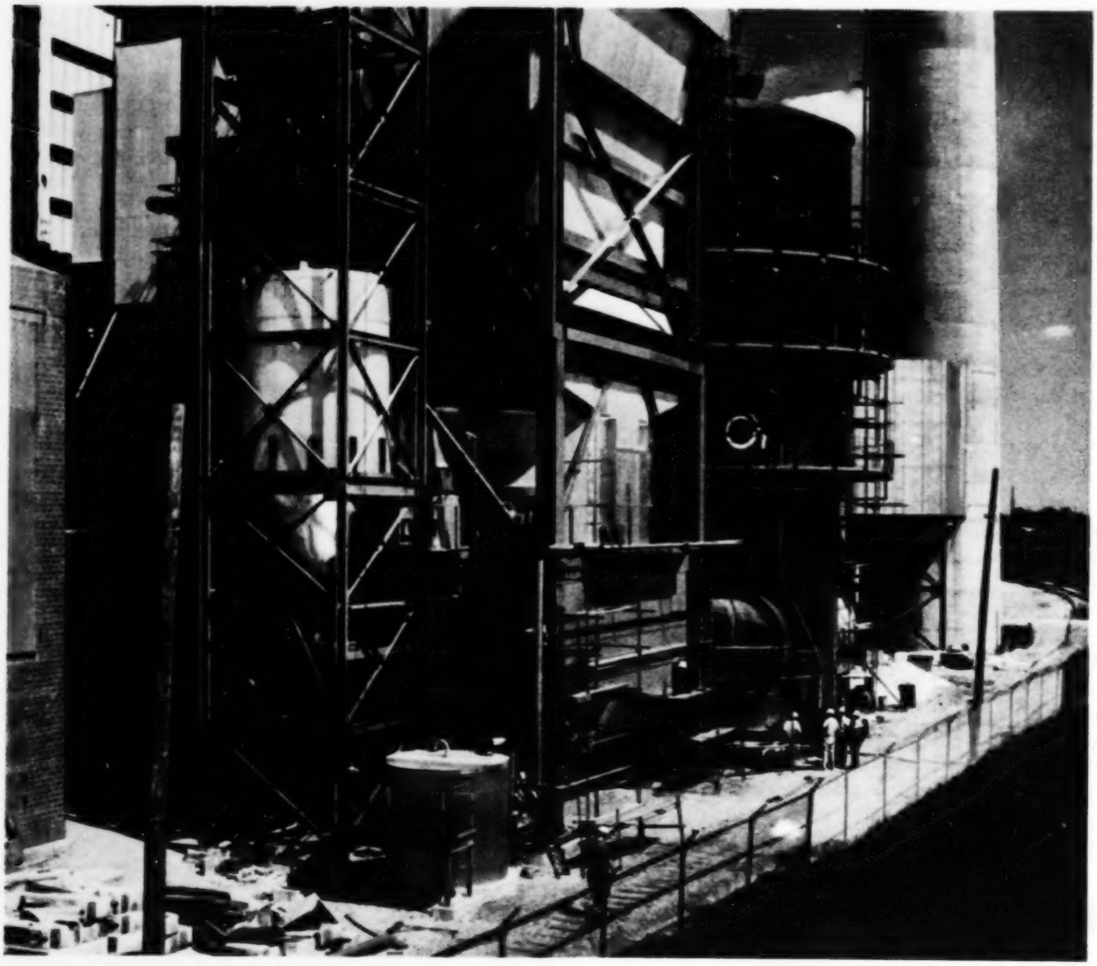
A new study with KVB, Inc., will evaluate the impact of fuel switching on industrial size boilers. Specifically, both high-sulfur bituminous and low-sulfur Western subbituminous will be burned in a variety of industrial boiler types and sizes. The impact on boiler performance and emissions will be assessed.

Field Testing – CSL has sponsored several field test programs, with boilers ranging from residential to utility size, to determine what can presently be done to control NO_x and combustible emissions. This work is done on commercial equipment and is generally performed by research and development organizations familiar with the specific combustion systems being studied using the financial and technical assistance of manufacturers, users, and trade associations. In addition to developing trends and providing directional recommendations for industry to use to minimize emissions using today's technology, the work also defines where the research and development efforts should be concentrated by developing emission factors as a function of equipment type and size, and fuel consumed. The field testing studies are the initial efforts in the development of control technology and are designed to provide the state-of-the-art in control of NO_x and combustible emissions from existing commercial combustion systems.

A study with residential (up to 300,000 Btu/hr) and commercial (300,000 to 10,000,000 Btu/hr) boilers was jointly sponsored by the American Petroleum Institute (API) and EPA. Battelle (Columbus) Laboratories, the contractor, concluded that emissions from this size range of equipment can be controlled best by proper burner design and proper maintenance.

A 2-year study of the effect of combustion modification on air pollutant emissions and efficiency of industrial (10,000,000 to 500,000,000 Btu/hr) boilers will be completed in the latter part of calendar year 1975. The contractor, KVB Engineering, Inc., field-tested 47 boilers (75 boiler/fuel combinations) during the first phase. The second phase will include longer term, more detailed tests on approximately 18 boilers. Extensive modifications (for example, flue gas recirculation and overfire air ports) will be performed and sampling will be extended to include toxic elements.

Field tests with utility (500,000,000 Btu/hr and greater) boilers have been performed by Exxon Research and Engineering Co. During 1971, the first year of the tests, 17 boilers (25 boiler/fuel combinations) that fired coal, oil, and/or gas were tested. Depending on boiler design, NO_x reductions averaging 60 to 70 percent were achieved with gas-fired units, and 50 to 60 percent with oil-fired units: initially, reductions with coal-fired units were not as successful. NO_x reductions on the gas- and oil-fired units were primarily achieved through low-excess-air-firing and staged combustion. In the past 2 years, emphasis has been placed on coal-fired boilers. Exxon was recently able to reduce NO_x emissions by an average of 40 to 50 percent by using low excess air and staged combustion on 12 coal-fired units without



Catalytic oxidation process for sulfur dioxide removal is in operation at Wood River Power Station in Alton, IL.

increasing other emissions or significantly affecting boiler performance. However, more information is needed to determine the effect of combustion modification with coal-fired units and tube-wall corrosion.

A follow-up study, jointly sponsored by EPA and the Electric Power Research Institute, is currently underway. Its primary purpose is to investigate potentially harmful side effects of combustion modification on utility boiler performance and tube-wall corrosion.

In the future, new burner designs will be tested in industrial and utility boilers, and testing will be conducted on such techniques as increasing fuel richness during staging of combustion. A wider variety of equipment types (such as kilns, ovens, process furnaces, gas turbines, and stationary internal combustion engines) will be investigated. The effect on emissions of mixed-fuel firing, fossil-fuel/waste-fuel firing, and firing coal-derived fuels such as low-Btu gas will be determined. These field tests will also provide badly needed information about emissions of toxic elements and potentially hazardous pollutants.

NO_x Program Summary – To date, it has been shown: that flue gas recirculation is the most effective combustion control technique for NO_x emission from nitrogen fixation of atmospheric nitrogen, and that staged combustion is the most effective control method for NO_x emissions from fuel nitrogen conversion. The development of this technology by the EPA has allowed the control of NO_x emission from gas- and oil-fired utility boilers to a level of 150 to 250 ppm. In short-term testing, combustion modifications have also resulted in NO_x reductions of up to 50 percent in commercial coal-fired utility boilers. In addition, burner and furnace design variables have been shown to cause widely varying NO_x emission levels in all boiler categories. Current efforts are directed toward the continued development and demonstration of modified operating procedures for NO_x Control in pilot- and commercial-scale utility and industrial boilers. Future work will support the establishment of New Source Performance Standards by applying the control technologies developed as a result of this research and development effort to pilot- and commercial-scale demonstration of combustion control of NO_x for existing and new combustion sources in all size categories. In addition, the research and development effort will be extended to develop control technology applicable to the combustion of additional fuel types (including coal-derived fuels such as low-Btu gas, mixed fuels, waste fuels, and methanol) and covering a wider range of combustion equipment (e.g., stationary gas turbines, internal combustion engines, and industrial process furnaces).

Hazardous and Other Pollutant Control

As EPA's regulatory program has developed, the number of pollutants requiring control has expanded to include more than 30 potentially hazardous and/or annoying air pollutants. The overall goal relating to hazardous and other (other than SO_x, NO_x and particulates) pollutants involves demonstration of the "best" technology for controlling pollutant emissions from specific combustion and industrial processes to such a degree that a net health benefit is realized with the least economic impact. Established technology can lead to setting New Source Performance Standards or Hazardous Emissions Standards.

Each of several hundred different industrial source types has a different degree of adverse environmental impact. The data base describing many of these source types is either non-existent or not in a form suitable for deciding on the need to develop control technology for the sources. A major effort is underway in CSL to generate the needed data base so that the environmental impact of the sources can be assessed accurately. Where currently installed control technology does not reduce emissions sufficiently for them to be of insignificant environmental impact, control technology must be developed. All options, including add-on devices, process changes, and raw materials changes, are considered in selecting the most attractive approach for technology development. The programs in the "hazardous" element therefore, involve either source assessment or technology development.

The goal of CSL's highly source-oriented control program for hazardous and other pollutants is to control all pollutants from a given source. For convenience in presentation, the extremely diverse program can be divided into six source categories: organic chemical processes, inorganic chemical processes, ferrous metals processes, non-ferrous metals processes, open sources, and hazardous pollutants from combustion sources.

Organic Chemical Processes – In the area of organic chemical processes, CSL's efforts are aimed at controlling emissions from asphalt roofing manufacture, ethylene dichloride manufacture, flare systems, Kraft pulping recovery processes, petroleum refineries, and rendering plants. Included in this category, along with rendering plants (because of their odor control relationship), are projects involving the adsorption properties of active manganese dioxide and charcoal.

Inorganic Chemical Processes – Relating to CSL's work with inorganic chemical processes, a program is underway to determine the need to develop control technology for fluoride emissions from gypsum ponds at fertilizer plants. Another ongoing project will provide data to quantify the capability of control equipment for enclosed asbestos sources; hopefully, these data will be used to strengthen the equipment standards for abestos control.

Ferrous Metals Processes – The ferrous metals industry converts iron ore and scrap iron into useful iron and steel products. At large integrated steel plants, iron ore, limestone, and coke are charged to a blast furnace where the iron ore is reduced to molten metal, which is periodically tapped. The iron from the blast furnace is saturated with carbon that must be removed to change it into steel. The iron from the blast furnace, usually molten, is generally mixed with cold scrap in a steelmaking furnace where it is blown with air or oxygen, which burns the carbon, to produce steel. It is in the steel furnace that the carbon level is reduced to the required level, impurities are removed, and alloying agents are added. (Other, less important, steel-making furnaces are the open-hearth and the electric arc.) The steel from the furnace is poured into ingots that solidify. The ingots are then adjusted to proper and uniform temperature and physically squeezed into the desired shape in rolling mills.

This sounds simple, but in reality it is rather complex as there are many ancillary processes and operations to contend with; e.g., sintering, coke production, scarfing, and galvanizing.

The iron and steel industry is not limited to large integrated plants; small iron and steel foundries are spread throughout the country. In these foundries scrap iron or steel is melted in electric arc and induction furnaces or in cupolas with little or no refining, then poured into molds to solidify into the desired shape.

Production of coke in conventional oven batteries has traditionally been a major source of particulates, SO_x, odors, carcinogens, and hazardous trace metals. It has been shown that top-side coke oven workers have a substantially higher risk of lung cancer than the average worker, probably from carcinogenic materials associated with the particulate fraction of the emissions. Until recently, emissions from this source have been relatively uncontrolled. Because the majority of existing cokemaking facilities will be operable for the next 25 years and because most facilities built in the next 10 years will feature conventional oven batteries, CSL has had to concern itself with developing control technology for conventional batteries in order to meet pollution control guidelines until the end of the century.

Present indications are that, even though pollution control technology may be developed for conventional batteries, equipment will probably be expensive and have high maintenance cost, yet may not be able to control all pollutants. The expected long-term solution to the coking problem is a continuous coking process that emits pollutants in a more controllable form. CSL's involvement in coking is ultimately expected to encompass continuous cokemaking.

Specific coke oven emission control projects with CSL involvement include: smokeless coke charging, enclosed coke pushing and quenching, smokeless coke pushing, and improved coke oven door seals. As shown in the accompanying figure, CSL's prototype demonstrations are expected to permit reduction of coke oven emissions from coke production. CSL is now expanding its outlook – initiating projects in other areas of the industry, in addition to cokemaking. Other major CSL ferrous emission control projects are related to sinter plant windboxes, basic oxygen process (BOP) furnaces, and iron foundry cupolas. New projects are being developed to control blast furnace and fugitive emissions.

Non-Ferrous Metals Processes – CSL's activities relating to non-ferrous metals processes – particularly relating to air pollution problems associated with primary copper, lead, and zinc production in the U.S. – began late in 1967 with a survey of sulfur oxides and particulate matter emitted by those industries. The study by Arthur G. McKee and Co., completed early in 1970, gave a general qualitative and quantitative status of emissions in the smelting industry.

The "McKee" effort was followed by another general study – this one to appraise the suitability of Monsanto's Cat-Ox process and the Wellmann-Lord process for controlling sulfur oxide emissions from copper, lead, and zinc smelters. The study was performed by Stanford Research Institute.

Because U.S. copper smelting exposes a significant segment of the population to a multiplicity of pollutants whose effects have not yet been determined, efforts are underway to evaluate emissions from such plants. CSL has also initiated a set of development projects. Two new efforts currently being mounted have as their respective objectives:

- Providing smelter-by-smelter information to EPA on the optimum application of currently demonstrated technology to simultaneously control all smelter streams containing SO_2 and particulates. The output will be in the form currently being accepted by the courts as demonstration by means of technology transfer.
- Assessing the environmental considerations of emerging technology for metal-winning in the primary non-ferrous industry. In this project, consideration will be given to hydrometallurgy as a new smelting process.

CSL and Phelps Dodge Corporation started a cost sharing study in July 1971 on a new SO_x control

Wet limestone (coral) scrubbing system for sulfur dioxide removal is in operation at oil-fired power plant in Key West, FL.

method based on reacting the SO_2 with H_2O, with sulfur values recovered as elemental sulfur. Initial attempts to generate the needed H_2S by roasting available copper ore with steam at 800°C showed that, although it was technically feasible, the economics were prohibitive. The emphasis has now shifted to leaching the concentrate with hydrochloric acid, which decomposes the pyrite and/or pychloric in the concentrate and releases ample quantities of H_2S. Preliminary results are promising; however, tests are required to understand the observed variations in H_2S generation as a function of the concentrate source.

EPA has entered into two separate Public Law 480 Agreements (excess foreign currency program) with Yugoslavia: one with the Institute for Copper, in Bor;

and the other with the Lead and Zinc Institute in Trepca. The Bor project is a 3-year investigation (begun in May 1971) being carried out at an American-engineered copper smelter, the largest in Europe. The Trepca project is a similar 3-year effort (started in October 1971) being carried out at a lead and zinc smelter.

Objectives of both projects are:

- To characterize quantitatively and qualitatively all air pollutant emissions from this type of smelter.
- To relate air pollutant emissions to the smelter feed and to feed changes so that data will apply to other smelters.
- To relate air pollutant emissions to operational changes (changes in smelter configuration) so that data will apply to other smelters.
- To determine the effects of controlling sulfur dioxide and particulates on the emission of all other pollutants, especially of the "hazardous" heavy metals.

The relationships that are being developed in these two Public Law 480 projects are expected to be applicable to the domestic non-ferrous smelting industry.

CLS's interest in hazardous and other emissions from the non-ferrous metals industry prompted a recently completed study at the South Dakota School of Mining under a research grant. The hazardous element of interest in this study was the mercury vapor or metallic mercury found in smelter or power plant flue gases.

Another CSL-funded effort relating to mercury and other hazardous pollutants (e.g., arsenic, cadmium, selenium, antimony, beryllium, copper, zinc, and lead) was a study completed by Monsanto Research Company to ascertain concentrations of these metals in smelter-produced sulfuric acid. The survey was intended to help predict the fate of hazardous pollutants produced by smelter sulfuric acid distribution to, and consumption by, different industries.

Open Sources – CSL's open sources program is a broad-based source characterization program, initiated to characterize all major sources of toxic emissions from mining and materials handling operations for the metallic ores and non-metallic minerals industries. Studies are underway: to identify heretofore unrecognized major sources of asbestos; to assess the importance of and develop control technology for asbestos mining sites; and to assess the importance of and develop control techniques for industrial wastes containing asbestos.

Hazardous Pollutants from Combustion Sources – CSL's program relating to the control of hazardous pollutants from combustion sources is closely coordinated with the Laboratory's particulate control, NO_x combustion, and SO_x flue gas cleaning programs. Because the initial emphasis is upon characterization of emissions from the most significant sources of pollution, the approach of the program is similar to that for industrial process control programs.

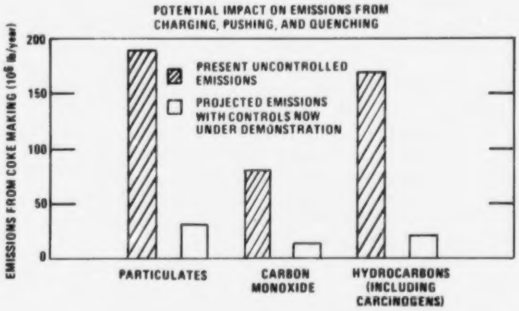
Coal-fired utility and industrial boilers were selected as being of highest priority. Midwest Research, selected as the contractor to characterize these sources for hazardous emissions, has developed a comprehensive test program covering all significant parameters that might affect toxic pollutant emissions. The program was prepared during 1973 with actual sampling beginning early in 1974.

In addition to the characterization of utility and industrial boilers, studies are being initiated to identify control alternatives for open combustion sources.

Energy Research and Development

A major effort has been underway since July 1973 to develop a plan for increased Federal support of energy research and development. As noted in the special Energy and the Environment section of this Report, the Control Systems Laboratory has provided substantial support to this planning activity and is expected to assume a major role in the implementation of the new energy programs. The accelerated

DEMONSTRATION COMPLETION DATE	
SMOKELESS COKE OVEN CHARGING	MARCH 1974
ENCLOSED COKE PUSHING AND QUENCHING	DECEMBER 1975
SMOKELESS COKE PUSHING	JUNE 1975



Control technology demonstration—coke making.

development of new energy processes requires an extensive technology assessment function within EPA.

The expanded control technology research and development program has resulted in increased budgets for EPA starting in Fiscal Year 1975. CSL has a leading role in the management of these funds; programs are being implemented through interagency agreements and activities conducted by other EPA laboratories that are coordinated by CSL, as well as through direct contracts to the private sector.

The significance to EPA of this energy research and development function cannot be overemphasized. During the next 5 years, decisions will be made and technology will be developed that will firmly establish the basis for the generation of energy for decades to come. These new energy technologies must be environmentally sound if the future health and welfare of the nation is to be protected. Although environmental considerations may be subjugated to short-term energy needs, there must ultimately be a reconciliation of energy and environmental considerations.

Active involvement by EPA will ensure that environmental control systems keep pace with new energy processes.

LEGISLATIVE MANDATE

The legislative mandates upon which CSL's several programs are based and the various Sections of the Clean Air Act requiring Laboratory support are shown below with a brief description of the types of actions taken to support that mandate or Section.

> **"RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES**
>
> **"Sec. 103. (a) The Administrator shall establish a national research and development program for the prevention and control of air pollution and as part of such program shall—**
>
> **"(1) conduct and promote the coordination and acceleration of research, investigations . . . demonstrations, surveys, and studies relating to the causes, effects . . . prevention, and control of air pollution. . . .**
>
> **"(b) In carrying out the provisions of the preceding subsection, the Administrator is authorized to—**
>
> **"(1) collect and make available, through publications and other appropriate means, the results of and other information . . . pertaining to such research. . . .**
>
> **"(8) develop effective and practical processes, methods, and prototype devices for the prevention or control of air pollution."**

In support of Sections 103 (a) and (b) of the Clean Air Act (cited above), CSL conducts studies and investigations to characterize emissions of pollutants, to evaluate control technology, and to predict the impact of and need for controls in the future. The Laboratory conducts research to develop cost-effective controls for pollutants from stationary sources and demonstrates the most promising control methods. Finally, CSL disseminates the research, development, and demonstration results to the public through seminars, professional meetings, and appropriate publications.

> **"RESEARCH RELATING TO FUELS AND VEHICLES**
>
> **"Sec. 104. (a) The Administrator shall give special emphasis to research and development into new and improved methods, having industry-wide application, for the prevention and control of air pollution resulting from the combustion of fuels. In furtherance of such research and development he shall—**
>
> **"(1) conduct and accelerate research programs directed toward development of improved low-cost techniques for—**
>
> **"(A) control of combustion byproducts of fuels,**
>
> **"(B) removal of potential air pollutants from fuels prior to combustion,**
>
> **"(C) control of emissions from the evaporation of fuels,**
>
> **"(D) improving the efficiency of fuels combustion so as to decrease atmospheric emissions, and**
>
> **"(E) producing synthetic or new fuels which, when used, result in decreased atmospheric emissions.**
>
> **"(2) provide for Federal grants . . . and contracts . . . for payment of (A) . . . cost acquiring . . . for research and development purposes, new or improved devices or methods having industry-wide application of preventing or controlling discharges into the air of various types of pollutants. . . .**
>
> **"(3) determine, by laboratory and pilot plant testing, the results of air pollution research and studies in order to develop new or improved processes and plant designs to the point where they can be demonstrated on a large and practical scale;**
>
> **"(4) construct, operate, and maintain, or assist in meeting the cost of . . . new or improved demonstration plants or processes which have promise of accomplishing the purposes of this Act. . . ."**

Through efforts provided for under Section 104(a) of the Clean Air Act (cited above), CSL has brought flue gas cleaning to the stage of commercial development, has developed techniques for the reduction of nitrogen oxide (NO_x) emissions from combustion processes by as much as 50 percent; has currently under demonstration a commercially feasible means of reducing carbon monoxide, hydrocarbon, and particulate emissions from coke ovens by 90 percent; has identified promising new combustion techniques such as the advanced power cycle and fluidized-bed combustion; and has developed effective low-cost processes for cleaning coal.

> **"AIR QUALITY CRITERIA AND CONTROL TECHNIQUES**
>
> **"Sec. 108 . . . (b) (1) Simultaneously with the issuance of criteria under subsection (a), the Administrator shall . . . issue . . . information on air pollution control techniques, which information shall include data**

relating to the technology and costs of emission control. Such information shall include such data as are available or attainable technology and alternative methods of prevention and control of air pollution. Such information shall also include data on alternative fuels, processes, and operating methods which will result in elimination or significant reduction of emissions."

In support of Section 108(b) of the Clean Air Act (cited above), CSL is continually evaluating new and existing stationary source control procedures in an effort to develop and maintain a comprehensive data base related to air pollution control techniques.

"(STATE) IMPLEMENTATION PLANS

"Sec. 110. (a) (1) Each State shall . . . adopt . . . a plan which provides for implementation, maintenance and enforcement of such primary (and secondary) standard. . . .

"(a) (2) (B) it (the plan) includes emission limitations, schedules, and timetables for compliance. . . .

"(e) (1) Upon application of a Governor . . . the Administrator may . . . extend (compliance period) . . . if . . . the Administrator determines that—

"(A) One or more emissions sources . . . are unable to comply with . . . standard because the necessary technology or other alternatives are not available. . . .

"(f) (1) . . . The Governor . . . may apply to the Administrator to postpone the applicability of such requirement to such source. . . . If the Administrator determines that—

"(B) such source (or class) is unable to comply with such requirement because the necessary technology or other alternative methods of control are not available or have not been available for a sufficient period of time . . .

"(D) . . . then the Administrator shall grant a postponement of such requirement."

The Laboratory's role in the procedures required by Sections 110 (a), (e), and (f) of the Clean Air Act (cited above) is primarily that of providing expert testimony relating to the availability of air pollution control technology. CSL's research, demonstration, and other evaluation tools provide the most comprehensive data base available concerning the state-of-the-art of air pollution control technology.

"STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES

"Sec. 111. (b) (3) The Administrator shall, from time to time, issue information on pollution control techniques for categories of new sources and air pollutants. . . .

"(d) (1) . . . each State shall submit to the Administrator a plan which (A) establishes emission standards for any existing source for any air pollutant. . . ."

CSL, in support Sections III(b) and (d) of the Clean Air Act (cited above), evaluates the state-of-the-air pollution control technology for various stationary sources and, based on projected future control needs, develops new control technology. The predicted new developments and schedules provide a basis upon which EPA can set future New Source Performance Standards. For non-criteria pollutants, the Laboratory's data base related to control capability and emission levels provides a basis upon which States may set emission standards for any pollutant from stationary sources.

"NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS

"Sec. 112. (b) (2) The Administrator shall, from time to time, issue information on pollution control techniques for air pollutants subject to the provisions of this section.

"(c) (2) The President may exempt any stationary source . . . if he finds that the technology to implement such standards is not available. . . ."

In support of Sections 112(b) and (c) of the Clean Air Act (cited above), CSL's programs will identify all air pollutants from stationary sources. As the need for control of these pollutants is indicated, through its related research and development program, the Laboratory will be able to identify not only the specific sources requiring control, but also the most cost-effective approach for achieving that control.

"COMPREHENSIVE ECONOMIC COST STUDIES

"Sec. 312. (a) . . . The Administrator . . . shall make a detailed estimate of the cost of carrying out the provisions of this Act . . . and a comprehensive study of the economic impact of Air Quality Standards on the Nation's industries, communities, and other contributing sources of pollution, including an analysis of the national requirements for and the cost of controlling emissions to attain such standards of air quality. . . ."

Among the activities of the CSL, related to Section 312(a) of the Clean Air Act (cited above), are research and demonstration projects leading to the development of comprehensive data relating to the cost of various air pollution control techniques.

Because CSL's programs simultaneously support numerous sections of the Clean Air Act, it is impossible to allocate a given resource to only one Section of the Act. For example, a CSL flue gas cleaning demonstration project supports Section 103 (Research, Investigation, Training, and Other Activities); Section 104 (Research Relating to Fuels and Vehicles); Section 108 (Air Quality Criteria and Control Techniques); Section 110 (State Implementation Plans); Section III (Standards of Performance for New Stationary Sources — in this case for electric utilities); and Section 312 (Comprehensive Economic Cost Studies).

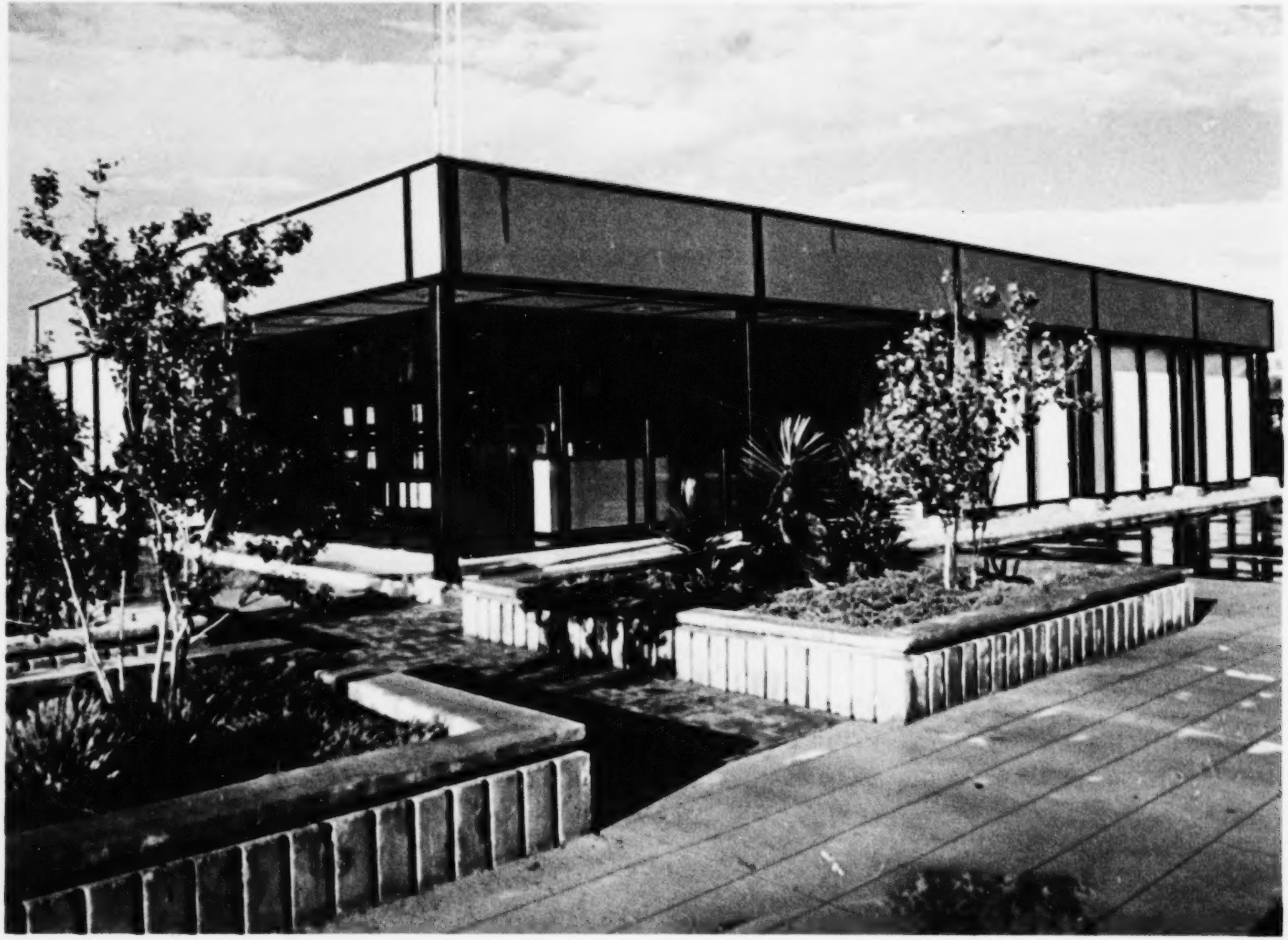
Thus, although Table 16 does not display a direct one-to-one relationship between projects and individual sections of the Clean Air Act, it does convey the general level of support that CSL's program provides to various sections of the Act.

Table 16. SUMMARY OF RESOURCES FOR CONTROL SYSTEMS LABORATORY FOR FISCAL YEAR 1975

Section of Clean Air Act Supported	Funds, $\$10^3$
103	3,329
104	2,929
108	1,598
110	1,598
111	3,035
112	799
312	27
Totals[a]	13,315

[a] Total does not include approximately $42.5 million of special energy appropriations.

Environmental
Monitoring
and Support
Laboratory



Quality Assurance and Environmental Monitoring Laboratory

OVERVIEW OF QAEML MISSION

The mission of the Quality Assurance and Environmental Monitoring Laboratory (QAEML) is to obtain the data needed to reach and support decisions concerning environmental quality and to develop and implement a total quality assurance program for all EPA-related air monitoring programs. Such data are needed in a variety of activities such as air quality management, criteria development, standards setting, compliance and enforcement, and development of source emission-control strategies.

In carrying out its mission, QAEML provides monitoring services that range from the first steps of any monitoring effort, such as selecting field sites for monitoring and making measurements on such sites, to the final steps of data evaluation, summarization, and dissemination. Quality assurance is practiced to control and document the quality of the data obtained. Although the use of standardized methods is an important aspect of quality assurance, such methods are not always available.

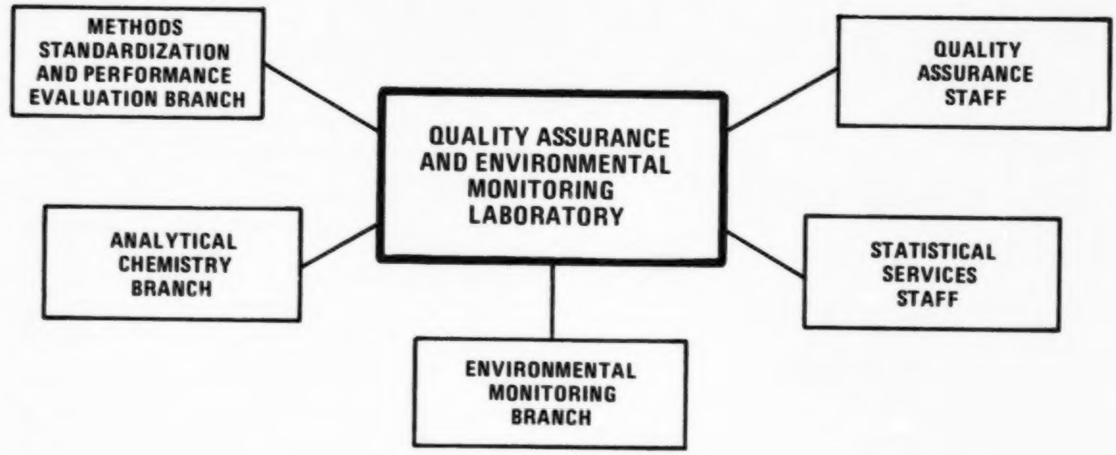
To supplement the use of standardized methods, QAEML maintains a staff of scientific and technical personnel having expertise in analytical chemistry, instrument electronics, and statistics to ensure that development and evaluation of methods, formal testing of methods (including collaborative testing in the community of users), and development of quality control procedures for methods are carried out effectively. Quality control procedures are formalized and disseminated for use within EPA, by the states, and by other interested groups.

Through appropriate statistical analyses, QAEML evaluates analytical methods and reduces and evaluates air quality data. These summaries and evaluations are provided for the community of users. Data are entered into the National Aerometric Data Bank or are published through appropriate channels.

ORGANIZATION

The Quality Assurance and Environmental Monitoring Laboratory conducts its activities through three technically oriented branches, a statistical staff, and a quality assurance staff, all of which report to the Office of the Director. The Branches are the Methods Standardization and Performance Evaluation Branch, the Analytical Chemistry Branch, and the Environmental Monitoring Branch. All activities are coordinated through the Office of the Director, which also serves as the interface with other EPA units for which QAEML provides technical support.

Specially designed facilities are used to gather pollutant concentration data and to test air monitoring methods and instruments.


METHODS STANDARDIZATION AND PERFORMANCE EVALUATION BRANCH
QUALITY ASSURANCE STAFF
QUALITY ASSURANCE AND ENVIRONMENTAL MONITORING LABORATORY
ANALYTICAL CHEMISTRY BRANCH
STATISTICAL SERVICES STAFF
ENVIRONMENTAL MONITORING BRANCH

Methods Standardization and Performance Evaluation Branch

The Methods Standardization and Performance Evaluation Branch (MSPEB) develops and conducts a program for standardization of methods that involves laboratory evaluation, procedure revision, and collaborative testing. The end products are standard analytical methods for the measurement of pollutant concentrations in ambient air and of source emissions. The Branch develops standard reference materials for use in methods standardization and calibration and in quality control and evaluation programs. MSPEB also conducts interlaboratory performance audits utilizing these standard reference materials.

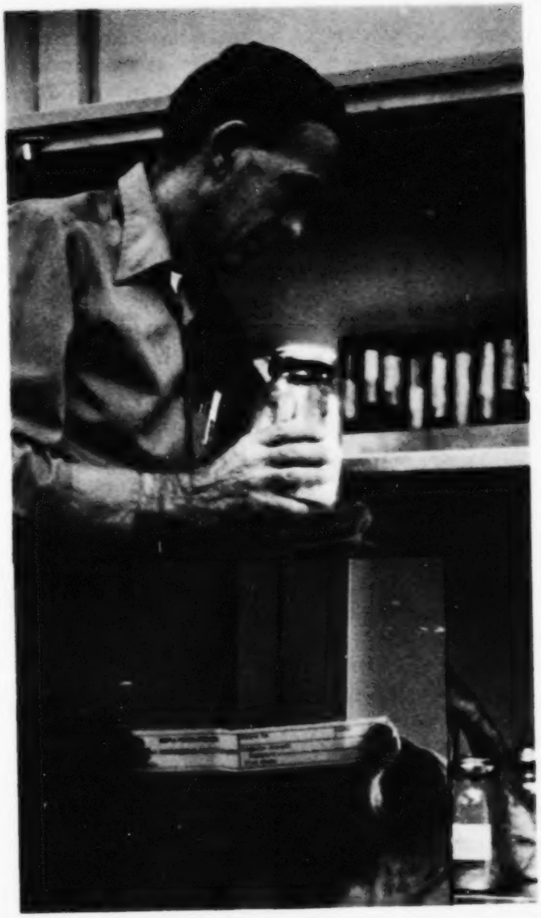
Analytical Chemistry Branch

The Analytical Chemistry Branch (ACB) provides analytical capability to ORD-RTP for the measurement of trace elements and other pollutants present in various environmental, bioenvironmental, source, and fuel samples. The Branch provides technical support and specialized training to EPA Regions and State and local agencies. As required, the ACB develops new methods, modifies existing ones, and provides analytical services in support of ongoing studies, including research monitoring. ACB is also responsible for maintaining liaison with and giving technical assistance to the Office of Air Quality Planning and Standards (OAQPS) in source sampling and in analysis for trace elements and other pollutants in order to provide valid data for development of source performance standards. Similar assistance is to be provided to the Office of Enforcement and General Counsel (OEGC) in support of the fuels and fuel additives monitoring programs, such as providing evidentiary support of the lead and phosphorus standards for gasoline for possible use in enforcement proceedings.

ACB personnel provide analytical laboratory services to OAQPS, OEGC, and other EPA organizations and programs for short-term and special environmental studies in support of monitoring trends in pollutant concentrations for State Implementation Plans and enforcement actions. The ACB is deeply involved in the quality assurance programs of ORD-RTP, regional laboratories, and other EPA components in performing referee analyses on diverse kinds of samples.

Environmental Monitoring Branch

The Environmental Monitoring Branch (EMB) is responsible for the installation, calibration, operation, and maintenance of special multi-purpose pollutant monitoring stations and networks such as the turbidity, precipitation, and membrane-filter particulate networks, and for providing guidance to other governmental agencies in the design and operation of monitoring stations and networks. The Branch provides specialized field monitoring support (including air sampling during emergency episodes) to OAQPS, OEGC, and the Regional Offices. Other areas of responsibility are the determination of equivalency of



Material samples involved in lawsuits are carefully handled to maintain chain-of-custody requirements and are sealed in locked storage cabinets (inset).

candidate methods and of instruments to be used in reference methods, and for the in-house and field evaluation of commercially available environmental monitoring instrumentation.

Quality Assurance Staff

The Quality Assurance Staff (QAS) provides guidance for development and implementation of quality assurance programs to ORD-RTP Laboratories, EPA Regional Offices, and state and local laboratories to ensure that all air pollution data used in the various decision-making processes are valid and comparable. The Staff formulates method-specific guidelines for the development and implementation of quality assurance systems for the measurement of pollutants in ambient air, from stationary and mobile sources, and in fuels and fuel additives. QAS also develops general guidelines, training materials, and procedures for objective assessment of air pollution data and for the on-site evaluation of quality assurance systems.

Statistical Services Staff

The Statistical Services Staff (SSS) participates in the statistical design, execution, and analysis of quality-assurance, methods-standardization, and monitoring studies. The Staff conducts mathematical and statistical evaluations and reports on internally generated data. This group is a focal point within ORD-RTP for handling, processing, and reporting aerometric data received from the World Health Organization (WHO) and from the World Meteorological Organization (WMO).

Analysis of phosphorus in gasoline is included in fuel tests conducted at ORD-RTP.

PHYSICAL FACILITIES

The Laboratory either owns or has access to a number of special instruments and facilities with which to support its mission.

The Durham Air Monitoring and Demonstration Facility (DAMDF) is a specially designed and equipped multi-purpose facility utilized for the following functions:

- To demonstrate advanced air monitoring techniques.
- To test and field-evaluate commercially available ambient-air monitoring instruments, calibration techniques, and data acquisition systems.
- To gather pollutant-concentration data generated from special intermethod comparability studies.
- To provide capability for equivalency testing of methods and instruments.
- To provide on-the-job training.

For special field studies, vans are available to carry calibration and maintenance equipment or for conversion on short notice into air monitoring stations. For projects requiring more elaborate air-monitoring equipment, personnel utilize mobile laboratories, which, when fully equipped, provide a facility for monitoring criteria pollutants and for measuring common meteorological parameters.

The analysis of samples by neutron-activation techniques is made possible by use of facilities leased from North Carolina State University. The University's pulstar reactor is used to irradiate the samples, which are later counted with QAEML-owned equipment located in the leased space.

QAEML has a 25-channel, direct-reading optical emission spectrometer that has been optimized for the determination of trace elements in particulate matter. A spark-source mass spectrometer that can be used to measure small concentrations of trace elements of possible health significance is utilized to permit analysis of environmental samples of interest, and to complement the neutron-activation capability. Rapid output of validated laboratory data is made possible by the use of dedicated minicomputers.

MAJOR PROGRAM AREAS

Methods Standardization and Performance Evaluation

Methods standardization and performance evaluation, which directly support Sections, 103, 110, 111, and 112 of the Clean Air Act, are important components of the quality assurance system necessary for generation of valid data. The standardization process is being applied to all reference methods given in regulations for primary and secondary national ambient air quality standards. Also, QAEML is standardizing some of the methods specified in regulations for new stationary sources and for two of the hazardous pollutants designated thus far: beryllium and mercury. Moreover, evaluations by the standardization process are being carried out for some methods not specified in regulations.

Measurement methods are standardized in a two-step process. First, the candidate method – that is a method proposed for publication as a reference method – is thoroughly examined in a single laboratory for the purpose of identifying and correcting errors, omissions, ambiguities, and other inadequacies. Second, the candidate method is examined in several laboratories by an interlaboratory collaborative test in which each participant uses the method to measure pollutants contained in a reference material. In this way, the precision and accuracy of the method are measured, and the capabilities of the method in the hands of typical users are estimated.

The levels of ambient air quality for each of the criteria pollutants must be measured by the appropriate reference method or by an equivalent method.

During 1974, efforts to standardize source-test methodology through a systematic program of method evaluation and collaborative testing were continued. To further these efforts:

- All planned field work on the evaluation and collaborative testing of the source method for visual opacity was completed.
- Reports were distributed on collaborative tests of source emission methods for nitrogen oxides, sulfur dioxide, particulates, Orsat gas analysis, velocity, moisture, and beryllium.
- A collaborative test of the analytical method for mercury indicated a need for improvement. An investigation was therefore initiated to modify the methodology to improve reliability.
- An investigation was initiated to study the design parameters and factors that affect the performance of the Type-S Pitot Tube.
- A collaborative test of the regulatory method for measuring carbon monoxide emissions from refinery catalytic-cracking regenerators was conducted, with the method found to be generally reliable.
- A field study was conducted on the regulatory method for measuring sulfur dioxide and sulfuric acid mist emissions using a ganged probe

Fuel additive samples are carefully catalogued prior to analysis and registration.

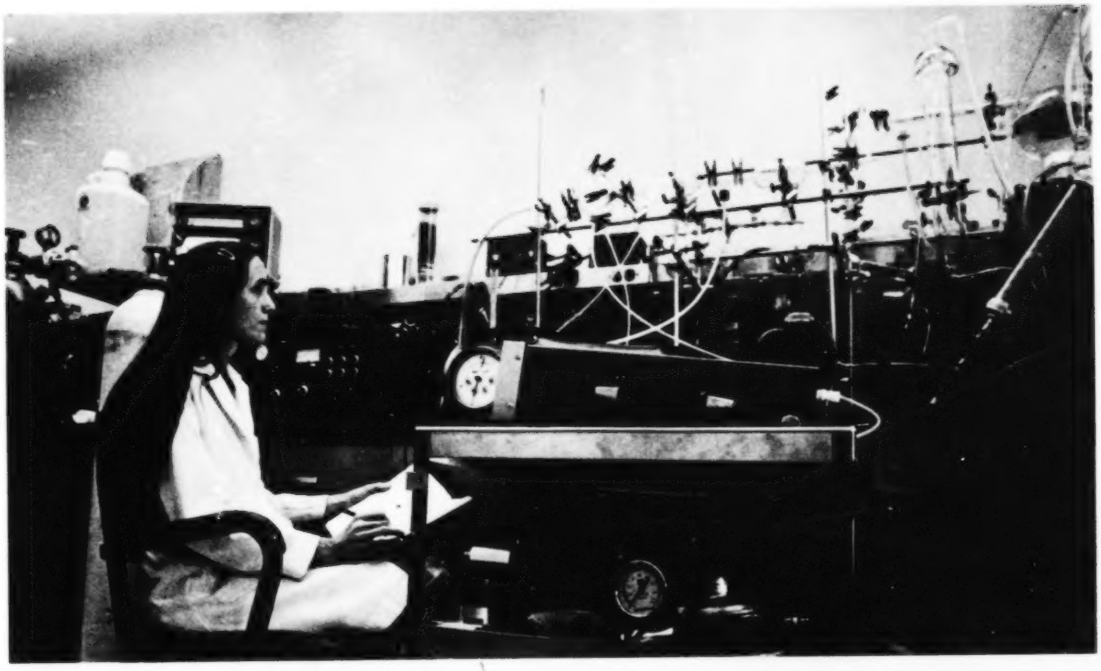
sampling assembly. The study indicates that, under rigidly controlled conditions, the sampling train is capable of giving reproducible results.

- Evaluation was started on the proposed regulatory method for measuring fluoride emissions from phosphate-fertilizer processes and primary aluminum reduction plants.
- Four of the regulatory methods promulgated with the New Source Performance Standards of December 23, 1971, were revised in accordance with results of the evaluation and collaborative test program.
- A study made of the Orsat gas analyzer versus the Fyrite gas analyzer indicated that under the conditions of the investigation, the Fyrite apparatus gives carbon dioxide and oxygen values comparable to the Orsat.

The Quality Control Section of MSPEB developed numerous quality control reference samples, both for routine and specialized pollutants. The number of interlaboratory performance surveys completed exceeded that of the previous year. One of the activities of this section is to develop estimates on the reliability of air pollution measurement techniques used in regional, state, and local laboratories. Accomplishments of the Section during 1974 included:

- Development and distribution of 1600 sulfur dioxide and nitrogen dioxide static samples.
- Refinement of the Hi-Vol flow calibration check device.
- Development of standard reference materials of lead in gasoline for use in enforcement in the unleaded gasoline rules and regulations.
- Development on charcoal tubes of quality-control samples for ambient-air vinyl chloride.
- Development of sulfate and nitrate quality-control glass fiber filter strips.
- Execution of four interlaboratory surveys, covering 595 participants measuring Hi-Vol flow, SO_2 (2), and CO.
- Direction of several special audits in Europe and the United States.

In efforts to standardize ambient-air methodology through a systematic program of method evaluation



Laboratory tests are used to evaluate various methods for measuring ambient pollutant concentrations.

and collaborative testing, the following investigations and studies were conducted.

- Experimental work to develop a reference material for NO_2 was completed. Plans were made by the National Bureau of Standards to issue an NO_2 permeation device as Standard Reference Material 1629.
- After withdrawal of the Federal reference method for ambient NO_2 in 1973, QAEML started a program for the evaluation and standardization of candidate methods with which to replace the withdrawn method. The program involved single-laboratory evaluation of five methods: two manual procedures, the Triethanolamine, guaiacol, sodium metabisulfite-8-amilino-1-naphthalene-sulfuric acid (TGS-ANSA) and triethanolamine methods; two instrumental procedures, the continuous chemiluminescence and the continuous colorimetric; and the sodium arsenite method. This work was followed by collaborative testing of all but the triethanolamine method. The first two evaluations were completed in 1973, and one was completed in 1974. It was found that in the hands of the average user the sodium arsenite, TGS-ANSA, and chemiluminescence methods are reliable, but that the continuous colorimetric method is not.
- A single-laboratory evaluation of two methods for measurement of ambient sulfates was started.

Priorities and plans for the coming year include a continuation of the ongoing projects for hydrogen sulfide, mercury, fluorides, and type-S pitot tube. The hydrogen sulfide, mercury, and fluoride investigations will probably culminate in collaborative tests of these methods. Since work to date indicates possible problems with the method for sulfur dioxide and sulfuric acid mist, further evaluation and possible modification of this method are also planned.

Because of recent information on the health hazards of vinyl chloride, EPA may soon establish an emission standard for this material. Since establishment of such a standard will necessitate a reliable standard method for vinyl chloride, an evaluation and testing program to provide the EPA with such a method is planned.

Other plans for 1975 include a comprehensive reevaluation of the EPA reference procedure for calibration of the chemiluminescence ozone instrument to determine its reliability; an evaluation of the non-methane hydrocarbon reference method; and an evaluation of a gas chromatographic method for analysis of vinyl chloride. Initiation of laboratory work on the vinyl chloride project is contingent upon satisfying safety requirements.

Quality Assurance Program

The quality assurance program conducted by QAEML, which directly supports Sections 110, 111, 112, 113, and 211 of the Clean Air Act, involves the development of guidelines for accomplishing the following objectives:

- Prevent accumulation of poor-quality data.
- Provide routine indication, for operating purposes, of satisfactory or unsatisfactory performance of personnel or equipment.
- Provide for prompt detection and correction of conditions that contribute to the collection of poor-quality data.
- Collect and supply information useful in describing the quality of the data.

Four guideline documents, each specifically applicable to one of the reference methods for ambient air, were published. Three guideline documents, each specifically applicable to one reference method for stationary sources, and two guideline documents, each specifically applicable to one of the reference methods for lead and phosphorus in gasoline, were developed and published. Similar documents are being prepared for other reference methods for stationary sources, hazardous pollutant source, and mobile source emissions.

The Quality Assurance staff also continued work on guidelines for the development of quality assurance programs for the new stationary-source performance reference methods and initiated preparation of guidlines for use with mobile-source reference methods. The group published and distributed guidelines on methods for measurement of lead and phosphorus in gasoline, as well as on methods for measuring velocity, carbon dioxide, and moisture in stack gases. Future QAEML research will be directed toward developing quality assurance guidelines for newly designated reference methods and toward revising previously published documents.

National Air Surveillance Network

The National Air Surveillance Network (NASN), operation of which supports Clean Air Act Section 103, is a network of 250 sampling sites located throughout the nation. Routinely, once every 12 days, the air at each site is sampled for particulates, sulfur dioxide, and nitrogen dioxide. The amount of particulate matter collected on glass-fiber filters and the nitrogen dioxide and sulfur dioxide levels are determined by regional laboratories, or by state or local laboratories within a region. The particulate matter samples are furnished to QAEML for analysis and incorporation in the sample bank.

Rapid generation of validated data is possible through QAEML's automated system of data acquisition and analysis, which has built-in quality assurance checks and numerical regression analysis routines, and which is programmed to yield precision data.

Some 60,000 analyses of particulate matter samples collected from 1970 through 1974 were conducted for non-metallic inorganics (sulfate, nitrate, and ammonium ions). Also, glass-fiber filters of low pollutant background were supplied by QAEML for NASN use in 1975 for monitoring particulates.

Continuous Air Monitoring Program

The Continuous Air Monitoring Program (CAMP), in support of Clean Air Act Section 103, provides a current and ongoing source of information on a wide range of problems associated with air monitoring and surveillance, including operation, maintenance, calibration, and evaluation of air monitoring equipment.

Continuous air monitoring instruments were evaluated and optimized during the year, and calibration techniques were developed to support regional needs. CAMP stations in Philadelphia, Denver, and Chicago were transferred to appropriate regional offices. Immediately before the transfer, the equipment was serviced, the instruments were calibrated, and the operators were trained. The exterior of the St. Louis station was replaced and incorporated into the Regional Air Monitoring System (RAMS). The Cincinnati station was disassembled and removed because the site lease could not be renewed.

The Durham Air Monitoring and Demonstration Facility (DAMDF) was utilized to conduct an NO_2 methods comparison study and to evaluate the proposed equivalency regulations. Four methods, currently being considered as candidates for a new reference method for measuring NO_2, were extensively evaluated during November and December of 1973 to determine the comparability of data collected by each method. The study was conducted at the DAMDF utilizing a special ambient air manifold system from which duplicates of each of the four methods could simultaneously sample ambient air spiked with various levels of NO_2. Data were collected continuously for 36 days under various conditions of NO_2 and other ambient pollutant levels. Results of this study are currently being evaluated and will be used to assist in the selection of a new reference method for nitrogen dioxide.

The latest available continuous monitoring instruments have been installed at DAMDF, including an improved system for environmental control and general building maintenance. This special multipurpose facility will then be used to demonstrate advanced air monitoring techniques, to test and field-evaluate commercially available ambient air monitors and associated calibration and data acquisition techniques to gather pollutant data, to conduct intermethod comparability studies, to provide on-the-job training, and to conduct equivalency testing. Operation of the Washington, D.C., station will continue, and updating of the station will be initiated as resources become available.

Fuels Surveillance Network

Fuels and fuel additives are collected nationally and analyzed for physical characteristics and chemical composition in support of Clean Air Act Sections 211 and 313. Analyses of the samples collected in 1973 were performed in 1974. A National Bureau of Standards (NBS) Standard Reference Material for lead in reference fuel was developed. A training program on sampling and analysis of unleaded gasoline was conducted for inspectors from all the Regional Surveillance and Analysis Divisions and for the Regional attorneys. Enforcement of the unleaded gasoline regulations was initiated, and necessary support was provided to OEGC, Mobile Source Enforcement Division.

QAEML contributed to the development of a field test for lead in unleaded gasoline (ASTM-D-3348). Also, the Laboratory contributed to the development of a simple but accurate field test for detecting lead, an atomic absorption spectrophotometric method for detecting lead in gasoline (ASTM-D-3237), and a method for detecting phosphorus in gasoline (ASTM-D-3231).

Fuels and fuel additives samples were analyzed to provide data for possible enforcement actions. Chain-of-custody was maintained so that samples could meet legal evidentiary tests. Samples for possible enforcement actions were analyzed as received since, in most cases, quick response was necessary. Programs were constructed for automated data acquisition and analysis, including analyses for determining precision for internal quality control.

Areas of future study include improvement of techniques for trace-element definition by spark-source mass spectrometry, neutron-activation analysis, and X-ray fluorescence. A computer program adjunct to neutron-activation analysis is being developed, and work is continuing on methodology for analysis of sulfur, lead, and phosphorus in fuels in support of the fuel regulations for OEGC.

Membrane Filter and Precipitation Networks

In support of Section 103 of the Clean Air Act, the 55-station membrane filter network for particulates was operated and maintained; samples were collected and analyzed for atmospheric pollutants of interest. Also, QAEML supported a 20-station precipitation network to be utilized ultimately for trace metals analysis. The network was operated jointly by EPA, the National Oceanic and Atmospheric Administration, and the World Meteorological Organization. Several programs were developed for automated data acquisition and analysis, some of which include built-in quality control checks.

During the year, archival samples collected by the 55-station network were analyzed for asbestos. Some 7,000 analyses were performed on precipitation network samples, with the data provided to interested parties. Membrane filter and precipitation monitoring for particulates and trace metals, respectively, will be maintained.

Technical Assistance and Rapid-Response Sampling Analysis

Much of QAEML's activity is in response to needs for technical assistance in other portions of EPA. A long-term study was initiated in Los Angeles, California, to determine the impact of emissions from the new automotive oxidation catalyst on the ambient air. Samples from the Los Angeles Catalyst Study (LACS) were analyzed for lead and for sulfate, nitrate, and ammonium ions to establish the validity of the reported results. Background data gathered from four stations at a site adjacent to the San Diego Freeway was initiated in May to identify existing air quality parameters prior to the appearance of the catalyst-equipped automobiles. The study, continuing into 1975, is designed to ascertain any resultant changes in the ambient sulfate/acidity levels and to determine related pollutant concentrations and meteorological and traffic parameters.

A vinyl chloride monitoring study was initiated. Actual analyses of vinyl chloride have been under the surveillance of the National Bureau of Standards, EPA Region IV, and Canadian laboratories as referee laboratories. Comparisons of data between laboratories show good correlation. Data from this study will be used to establish standards.

At Kellogg, Idaho, QAEML consulted with EPA Regional Offices on ambient air monitoring methodology for criteria and non-criteria pollutants. Samples (from the contractors working for EPA Region X) and several hundred other samples from special and routine studies were analyzed for lead.

QAEML also provided technical assistance by analyzing fuels used in high-density population apartment complexes in New York State. Analytical support, in the form of analyses of soil and vegetation samples taken in and around an Ohio Brass Works, was furnished to Ohio State University. In assistance to the Community Health Air Monitoring (CHAMP) project, several hundred referee samples were analyzed for nonmetallic inorganic ions. Plans are being developed for a more formal arrangement for QAEML's involvement in the quality assurance program of this project. Samples obtained from OAQPS were analyzed to determine background information for standard setting for industrial sources.

QAEML's participation in other activities during 1974 included the following:

- Operation of 20-site nitrogen dioxide monitoring network with continuous chemiluminescence instruments gathering data for possible reclassification.
- Investigations to support the publication of methods for fluoride in the *Federal Register.*
- Consultation to the World Health Organization in the development of an International Air Pollution Monitoring System.
- Participation in a project to determine ambient hydrocarbon concentrations.
- Involvement in a cooperative air monitoring comparison study involving the USSR and the USA in Leningrad, U.S.S.R.
- Continuation of operation of the Washington, D.C. station, with calibration, supplies, and equipment provided by EMB and daily operation provided by the District of Columbia.
- Comparative study of nitrogen dioxide methods to provide a basis for recommending a new reference method for nitrogen dioxide.
- Evaluation of the High-Volume Method for determining suspended particulates over short sampling times (contract effort).
- Performance of a 3-month urban ozone study in the Ohio Valley in support of an OAQPS contractual effort to determine possible ozone transport.
- Execution with a contractor's assistance, of a comprehensive quality assurance program for the Ohio Valley oxidant study.
- Provision of assistance to a contractor at the request of OAQPS in carrying out a complex source study at a shopping center in Oakbrook, Illinois.

LEGISLATIVE MANDATES

The mission of QAEML responds to eight sections of the Clean Air Act (103, 108, 110, 111, 112, 113, 211, and 313). The various sections are shown below with brief descriptions of the types of supportive activities.

> **"RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES**
>
> **"Sec. 103. (a) The Administrator shall establish a national research and development program for the prevention and control of air pollution and as part of such program shall—"(1) conduct and promote the coordination and acceleration of, research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, and control of air pollution; . . . (3) conduct investigations and research and make surveys concerning any specific problem of air pollution in cooperation with any air pollution control agency with a view to recommending a solution of such problem, if he is requested to do so by such agency or if, in his judgment, such problem may affect any community or communities in a State other than that in which the source of the matter causing or contributing to the pollution is located; . . .**
>
> **"(b) In carrying out the provisions of the preceding subsection the Administrator is authorized to—**
>
> **"(1) collect and make available, through publications and other appropriate means, the results of and other information, including appropriate recommendations by him in connection therewith, pertaining to such research and other activities; . . . ."**

QAEML responds to Section 103 by evaluating, testing, and standardizing methods. Quality control procedures for relevant methods are also developed. Surveys and investigations are undertaken, both of the general extent of air pollution and of specific problems. The voluminous data that result are appropriately summarized, analyzed, and disseminated.

> **"AIR QUALITY CRITERIA AND CONTROL TECHNIQUES**
>
> **"Sec. 108. (a) (2) The Administrator shall issue air quality criteria for an air pollutant within 12 months after he has included such pollutant in a list under paragraph (1). Air quality criteria for an air pollutant**

shall accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare which may be expected from the presence of such pollutant in the ambient air, in varying quantities . . .

"(c) The Administrator shall from time to time review, and, as appropriate, modify and reissue any criteria or information on control techniques issued pursuant to this section . . . ."

QAEML responds to this section of the law by standing ready to evaluate methodology used to obtain scientific information or to undertake surveys to obtain information needed by those who must develop criteria documents.

"IMPLEMENTATION PLANS

"Sec. 110. (a) (1) Each State shall, after reasonable notice and public hearings, adopt and submit to the Administrator, within nine months after the promulgation of a national primary ambient air quality standard (or any revision thereof) under section 109 for any air pollutant, a plan which provides for implementation, maintenance, and enforcement of such primary standard in each air quality control region. (or portion thereof) within such State. In addition, such State shall adopt and submit to the Administrator . . . a plan which provides for the implementation, maintenance, and enforcement of such secondary standard . . .

"(2) . . . The Administrator shall approve such plan . . . if he determines that it was adopted after reasonable notice and hearing and that—. . . (C) it includes provision for . . . appropriate devices, methods, systems, and procedures necessary to (i) monitor, compile, and analyze data on ambient air quality . . . ."

This section of the law is supported by QAEML's activities in the evaluation and standardization of methods for the criteria pollutants and in the development and dissemination of quality control procedures for standardized methods. Use of the standardized methods with quality assurance documentation provides the ability to meaningfully compare data collected routinely by many unrelated State agencies.

"STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES

"Sec. 111. (b) (a) (B) . . . the Administrator shall propose regulations, establishing Federal standards of performance for new sources . . .

"(c) (1) . . . If the Administrator finds the State procedure is adequate, he shall delegate to such State any authority he has under this Act to implement and enforce such standards . . . ."

This requirement is analogous to that of Section 110 of the Act; QAEML supports this section similarly.

"NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS

"Sec. 112. (b) (1) (B) . . . the Administrator shall prescribe an emission standard for such (hazardous) pollutant . . .

(d) (1) . . . If the Administrator finds the State procedure is adequate, he shall delegate to such State any authority he has under this Act to implement and enforce such standards . . . ."

This requirement is similar to those of Sections 110 and 111 of the Act. QAEML's support is also in terms of methods standardization, evaluation, and quality control procedure development. Some technical assistance is also rendered to obtain data with which to assist the Administrator in making judgments as to what constitutes a hazardous pollutant.

"FEDERAL ENFORCEMENT

"Sec. 113. (a) (1) Whenever, on the basis of any information available to him, the Administrator finds that any person is in violation of any requirement of an applicable implementation plan . . . the Administrator may issue an order requiring such person to comply with the requirements of such plan or he may bring a civil action . . ."

QAEML maintains a limited rapid-response capability in the collection of data for purposes of Federal enforcement.

"REGULATION OF FUELS

"Sec. 211. (a) The Administrator may by regulation designate any fuel or fuel additive and, . . . no manufacturer or processor of any such fuel or additive may sell, offer for sale, or introduce into commerce such fuel or additive . . ."

QAEML's support of the law consists of the development and evaluation of methods of analyses and of the collection and analysis of fuel samples as required.

"ADDITIONAL REPORTS TO CONGRESS

"Sec. 313 . . . the Administrator shall report to the Congress on measures taken toward implementing the purpose and intent of this Act . . ."

When the inclusion of data, methods, or method modifications developed by QAEML is relevant, the information is provided in support of this provision of the Act.

Table 17 contains a summary of the resources employed by QAEML for Fiscal Year 1975 in support of the applicable sections of the Clean Air Act.

Table 17. SUMMARY OF FUNDS FOR QUALITY ASSURANCE AND ENVIRONMENTAL MONITORING LABORATORY FOR FISCAL YEAR 1975

Section of Clean Air Act[a] Supported	Funds, $\$10^3$
103	1,115
108	107
110	1,485
111	525
112	415
113	173
211	310
313	180
Total	4,310

[a] Related information is provided in section entitled Legislative Mandates.

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